VOL. 56 JUNE, 1940 No. 1

JOURNAL

OF THE

Elisha Mitchell Scientific Society

CONTENTS

A Systematic Study of the Genus Arctostaphylos Adans. *J. E. Adams* 1

A County Check List of North Carolina Ferns and Fern Allies. *H. L. Blomquist and D. S. Correll* 63

Species of Oedogonium New to South Carolina. *P. J. Philson* 106

A New Turbellarian Worm (Rhabdocoele) from Beaufort, North Carolina, Phonorhynchus pearsei n. sp. *F. F. Ferguson, M. A. Stirewalt, and W. A. Kepner* 111

A New Turbellarian Worm (Alloeocoele) from Beaufort, North Carolina, Archiloa wilsoni n. sp. *M. A. Stirewalt, William A. Kepner, and F. F. Ferguson* 123

A Two-headed Embryo of the Pipefish, Syngnathus floridae. *Louella E. Cable* 135

Structure and Development of the Seed of Cynoglossum amabile Stapf & Drumm. *Vera Millsaps* 140

Studies in the Genus Olpidiopsis. III. *Leland Shanor* 165

Notes on Plankton Entomostraca of the Carolinas. *Paul W. McKee and R. E. Coker* 177

CHAPEL HILL, N. C., U. S. A.

The Elisha Mitchell Scientific Society

ENGLISH BAGBY, President

E. L. MACKIE, Vice-President

E. T. BROWNE — Permanent Secretary

J. E. ADAMS — Recording Secretary

EDITORS OF THE JOURNAL:

W. C. COKER, Chairman

C. D. BEERS

OTTO STUHLMAN, JR.

JOURNAL OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY—Semi-annual. Price $3.00 per year; single numbers, $1.50. Direct all correspondence to the Permanent Secretary, at the University of North Carolina, Chapel Hill, N. C.

In addition to original papers on scientific subjects, this Journal publishes the Proceedings of the Elisha Mitchell Scientific Society, and the Proceedings of the North Carolina Academy of Science, as well as abstracts of papers on scientific subjects published elsewhere by members of the faculty of the University of North Carolina.

PUBLISHED FOR THE SOCIETY

BY THE

UNIVERSITY OF NORTH CAROLINA PRESS

Made in the United States of America

JOURNAL

OF THE

Elisha Mitchell Scientific Society

Volume 56 June, 1940 No. 1

A SYSTEMATIC STUDY OF THE GENUS ARCTOSTAPHYLOS ADANS.

By J. E. Adams

HISTORICAL INTRODUCTION

Adanson (5) published the name *Arctostaphylos* in 1763 to reinstate *Uva Ursi* of Tournefort (71) which Linnaeus (49) had included in *Arbutus*. In 1790 Necker (54) published the generic name *Mairania* also as a monomial synonym for *Uva Ursi* Tourn. Desvaux (9) applied this name in the same sense, but Britton (7) interpreted Desvaux's treatment as a distinctive name for the Alpine Bearberry, *Arbutus alpina* L.

In 1910 Williams (73) revived the name *Uva-ursi* (with hyphen) on the basis of its use by Miller (53) in 1754, nine years before the publication of *Arctostaphylos* Adans. This name has been taken up by others (1). The inadmissibility of the name was pointed out by Jackson (40) on the basis of the treatment of analagous cases by Linnaeus (Phil. Bot. p. 160, 1751), and is specifically covered by Article 67 of the International Rules of Botanical Nomenclature (1930).

In 1837 Zuccarini (74) published the genus *Comarostaphylis*, as a segregate of *Arctostaphylos*, basing the distinction chiefly on the fleshy papillate fruit of the former. Plants grown from seed collected in southern Mexico served as the type. General agreement as to the validity of the genus is wanting. Since the publication of the genus, its species have been transferred back and forth *en masse* between *Arctostaphylos* and *Comarostaphylis* by various authors. Klotzsch (45) appears to have been the first to attempt a general rearrangement of

the species of *Arctostaphylos*. He transferred ten species previously known under *Arctostaphylos* to *Comarostaphylis* and described new ones. In 1881 Hemsley (33) reduced *Comarostaphylis* to synonymy and transferred its species to *Arctostaphylos*. Small (66) in 1914 restored *Comarostaphylis*, and more recently Standley (70) has again reduced it to synonymy with *Arctostaphylos*. Jepson (43) recognizes *Comarostaphylis*.

Nuttall published *Xylococcus* (57) and *Xerobotrys* (57) in 1843, the former as a new genus based on *X. bicolor* of southern California, which differs in flower and fruit and presents an aspect rather different from *Arctostaphylos*, the latter as a segregate of *Arctostaphylos*, based on a supposed difference in fruit. *Xylococcus* was treated as a section of *Arctostaphylos* by Asa Gray (25) in 1868 and has been reduced to synonymy with *Arctostaphylos* by Jepson (41) and by Standley (70).

In 1851 Klotzsch (45) included in *Arctostaphylos* only *Arbutus alpina* L. and *Arbutus uva ursi* L., describing the fruit as juicy. He erected the genus *Daphnidostaphylis* to contain the other species with fleshy fruit. The name appears never to have been used by other botanists.

The Alpine Bearberry, *Arbutus alpina* L., with juicy fruit and deciduous or marcescent leaves was taken as the basis for the section *Arctous* by Asa Gray (28) in 1878. Niedenzu (55) subsequently elevated this section to generic rank.

In 1914 Small (66) erected the genus *Ornithostaphylis* to contain the Lower Californian *Arctostaphylos oppositifolia* Parry, with its much branched panicle and opposite leaves.

The most recent of the proposed segregates of *Arctostaphylos* is that of Eastwood (19) who at first included under the generic name *Schizococcus*, *Arctostaphylos nummularia* Gray, *A. myrtifolia* Parry, and *A. sensitiva* Jepson on the basis of the thin pericarp and the tendency of the fruit to separate into one-seeded parts and fall early. The first two had previously constituted the section *Micrococcus* of Parry (58). Eastwood has recently (22) added to *Schizococcus* the little known *A. nissenana* Merriam.

The history of the description of species of *Arctostaphylos* is confusing because of the diverse treatment accorded the various generic segregates. Listing the number of species included under the name *Arctostaphylos* by various authors gives little clue to the actual size of the genus. For the purpose of sketching the progress of this work the present writer considers as distinct from *Arctostaphylos* the following segregates: *Comarostaphylis, Xylococcus, Ornithostaphylis.*

In 1814 Pursh (64) recognized two species from North America. One of them, *A. tomentosa* (Pursh) Lindl. collected on the "Northwest coast of America" by Menzies, was destined to become the dumping ground for many diverse forms. *A. pungens* H.B.K. was described in 1819 (39) from the vicinity of Mexico City. Asa Gray, in the Botany of California (1876), included seven species, and in the Synoptical Flora of North America (1878), nine species and one variety. Parry (60) in 1888 admitted thirteen species and one variety. In 1914 Abrams (1), employing the revived generic name *Uva-Ursi*, recognized twenty-three species for North America. Twenty-four species and six varieties were recognized by Jepson (43) in 1925. Eastwood (20) included fifty-three species and six varieties for North America, north of Mexico, in 1934. Thirty-three species, three subspecies, and nineteen varieties are recognized in the present treatment.

RELATIONSHIP WITH ALLIED GENERA

Drude (11) included in Arbuteae *Arbutus*, *Arctous*, and *Arctostaphylos*, and treated as subgenera under the last *Xylococcus* and *Comarostaphylis*. As previously indicated, these units have been variously treated. To the list should be added *Ornithostaphylis* and *Schizococcus*. Whatever taxonomic rank is accorded them, these segregates constitute a closely related group and possess interesting combinations of characters.

Arbutus occupies a distinct position within the group by virtue of its fleshy fruit with granular-papillate pericarp and many small seeds, several in each of the five cells. In the remainder of the series the ovules are borne singly within the cells. In development the endocarp becomes bony and the mature fruit may contain several one-seeded nutlets, or these may by apparent coalescence become a single stone. In certain of the genera the completely coalesced condition of the nutlets is constant, while in others it is extremely variable. This latter fact has played considerable part in the interpretation of these generic segregates by various authors. The pericarp presents fairly constant features within the various genera.

Arctostaphylos produces a smooth, globular, or somewhat flattened fruit with a dry granular, mealy, or sometimes leathery pericarp enclosing 4–10 one-seeded nutlets, or these may be fused into a single solid stone. In habit, the species of this genus vary from prostrate to shrubby and subarborescent, but the smooth, dark red bark and erectly borne leaves mostly alike on both surfaces present a unity of aspect very distinct from the other genera.

Of the proposed segregates *Schizococcus*, founded upon *Arctostaphylos nummularia* Gray, is most closely related to *Arctostaphylos*. Its flowers are 4- or 5-merous and the fruit contains 2–5 one-seeded nutlets surrounded by a very thin pericarp which disintegrates soon after the fall of the fruit. The fruits are rather uniformly small, 3–4 mm. in height and 2–3 mm. broad. The plants, however, possess all the characteristics contributing to the distinctive general aspect of *Arctostaphylos* and the behavior of the fruit appears to be a matter of degree, the early liberation of the nutlets being due to the extreme thinness of the pericarp.

Comarostaphylis, based upon *C. arguta* Zucc. of Mexico, occupies a position somewhat intermediate between *Arbutus* and *Arctostaphylos*. Its fruits are globose, fleshy, and granular or papillate, the pericarp consisting of clavate granules attached at the base. The stone, however, is solid and 3–5-celled with a single seed in each cell. The inflorescence and the leaves, as well as the fruit, lend a pronounced *Arbutus*-like aspect.

Xylococcus, founded upon *X. bicolor* Nutt. of southern California and Baja California, produces a smooth brownish red or blackish fruit with a single, smooth, usually 5-celled stone and thin dry pulp, the whole resembling the fruit of *Arctostaphylos*. The fused condition of the nutlets which Nuttall indicated as a prominent generic character is probably the least important. The grayish rough bark, the somewhat spreading, revolute and strongly bifacial leaves, as well as the inflorescence, contribute to an aspect quite unlike that of *Arctostaphylos*.

Ornithostaphylis Small, a monotypic genus of northern Baja California, founded upon *Arctostaphylos oppositifolia* Parry, is distinctive among these related genera in the production of numerous linear, verticillate or opposite leaves which are strongly revolute. The inflorescence is a densely flowered much-branched panicle; the fruit is of the *Arctostaphylos* type, smooth, with separable nutlets and thin dry pericarp.

Arctous Niedenzu, founded upon the Alpine Bearberry, *Arbutus alpina* L., although showing a relationship to *Arctostaphylos* in its variously separable one-seeded nutlets, differs in its juicy pericarp, its inflorescence of few clustered flowers, and in its deciduous or marcescent leaves.

TAXONOMIC CRITERIA

Arctostaphylos is a genus of evergreen woody plants found growing for the most part under more or less xeric conditions. The thick and

coriaceous, erectly borne leaves with both surfaces similar are typical of xerophilous plants. The flower buds are generally formed late in the previous season and anthesis is usually occasioned by the first sustained rise in temperature after the winter rains.

The delimitation of satisfactory units within this genus is difficult. Many characters which appear at first to be of taxonomic value break down under the examination of extensive series. The writer has attempted to test during the course of this study, both in the field and herbarium, the value of the many characters that have been employed. It became clear early in the course of the investigation that in the majority of cases a very liberal interpretation of specific characters must be made if a disproportionate view of the importance of many relatively minor variations was to be avoided.

The importance of field study of the living plants cannot be overemphasized. Characteristics of habit, manner of branching, and hue of foliage cannot be seen in their true light in herbarium specimens, and collectors' labels are commonly without data on these points. Yet to the observer in the field differences in these characters are obvious and unmistakable.

A characteristic of great importance first noted by Jepson in 1916 (41) and applied by him in 1922 (42), and one well worth the trouble to observe, is the behavior of the plant in reference to fire. Certain species appear to have become adapted to the periodic recurrence of fire. In some species this adaptation has taken the form of a great enlargement of the root-crown from which, after destruction of the stem by fire or mutilation, young sprouts arise in great numbers. The enlargement of the root-crown, observable in very young plants as a small knob at the base of the stem, increases as the plant grows and may attain a considerable size, being generally globose. Under the influence of recurring fires the lateral expansion of the root-crown is such as to form, in old shrubs of some species, extensive tabular platforms at or just below the surface of the soil.

The important fact from our point of view is that the production of an enlarged root-crown is a definite and constant feature in certain species and recognizable at all stages of development. This feature, therefore, has considerable taxonomic value and in the present treatment observations on this point are included as a part of the regular diagnoses. Much ecological importance attaches to the ability of these species to regenerate a new top by sprouting from the enlarged root-crown after fire.

Other species produce no enlarged root-crown and are killed outright

by fire. Such non-sprouting species, however, appear to produce fruits and seed in greater abundance than the sprouting species, and at a much earlier stage of development, often when only a few inches high.

Glandularity of various parts of the plant has been extensively used in species delimitation, applied both in terms of degree and of presence or absence. Glandularity, or the lack of it, has been shown in several important instances to be one extreme of a long series embracing both conditions. Considered apart from other characters glandularity frequently leads to erroneous conclusions regarding relationship.

The grosser characters of the leaves are rather uniform throughout the genus. Although specific differences are observable, especially in terms of color, texture, shape, presence or absence of petiole, etc., these characters are of no value in indicating relationships between species. However, certain closely related species among the root-crown sprouters in the Coast Ranges can be definitely placed in natural groups on the basis of the distribution of stomata and shape of leaf base. Thus *A. glandulosa* and its close allies can be distinguished as a group on the basis of the acute or obtuse leaf base with stomata distributed on both surfaces of the leaves from the large number of forms comprising the *A. crustacea-A. tomentosa* alliance with their truncate or subcordate leaf bases and stomata on the lower leaf surface only. On the other hand, such a distinctive character as sessile leaves with auriculate bases is of little help in this respect as shown by *A. pechoensis* which is probably more closely related to *A. canescens*, a typically petiolate species, than to the sessile-leaved *A. andersonii*.

The general aspect of the inflorescence, dependent upon such characters as degree of branching, disposition of the branchlets, pedunculate or sessile character, abundance of flowers, etc., appears to be the most reliable index to relationship within the genus. The bracts of the inflorescence, insofar as they contribute, according to their size and texture, to the general aspect of the inflorescence, are useful in indicating broad lines of relationship, but within any group of closely related species are of little value as specific criteria. The glabrousness, pubescence, or glandularity of the pedicels is usually fairly constant within a given species, although many instances are noted in which the character is variable, especially in species of wide geographic range.

The bark of older stems is a striking feature of the shrubs. It is predominantly smooth, thin, of a deep mahogany or chocolate brown color and a dull lustre. During the period of active growth the bark is shed in thin flat plates, scales or curls which in most species promptly

fall, exposing the new lighter colored bark. However, three or four forms are noteworthy in that the old bark exfoliates in rather long shreds or strips which may persist upon the stems for several years, eventually assuming a bleached, grayish aspect. This gives the stems of such forms a very distinctive shaggy appearance.

Enclosed within the fruit pulp is a radiating series of bony nutlets varying in number from 4 or 5 to 8 or 10. These nutlets are either loosely united and easily separable or may be irregularly coalesced in 2's and 3's or sometimes completely fused into a single solid 5- to 10-celled stone. Although some species consistently produce solid stones, due to the great variability in this character within the genus as a whole, this tendency to complete coalescence can be given only minor weight unless accompanied by other distinctive features.

Ecological data when more fully worked out for the species will prove valuable. In the Sierra Nevada the altitudinal ranges of the species are striking and correspond to certain definite sets of ecological factors. The Sierra Nevada supports a relatively small number of well defined species, which fact reflects the general uniformity of environmental conditions in the various horizontal zones. In contrast, the Coast Ranges display a very large number of forms, many of them poorly defined. Detailed ecological studies undertaken in connection with the multitude of forms in the Coast Ranges where climatic and edaphic factors change abruptly from place to place may yield some interesting correlations.

In the present study geographical distribution has been found especially helpful in the elucidation of groups of closely related forms of wide range. Detailed plotting of the range at once reveals the relative importance of the units of a complex. Thus, in treating the difficult group of root-crown sprouters in the Coast Ranges, geographical distribution has been given considerable weight in determining the disposition to be made of the various morphological units.

From the above brief discussion it may be apparent that no one feature or set of features is applicable throughout the genus as a criterion of species. On the contrary, specific limits can be ascertained only by analyzing the combinations of characters as they occur. In a genus of such closely similar yet diverse forms the examination of very extensive series in the field and herbarium coupled with distributional studies is the only approach likely to lead to a correct interpretation of the forms.

The term *species* is used in the present treatment to denote natural populations of individuals morphologically alike, distinct from other

such populations, and possessing a more or less coherent and consistent geographic range. The question of interspecific hybrids and its bearing upon species delimitation within the genus is a subject for investigation. Apparent intermediates between admitted species are frequently encountered. The term *subspecies* is used approximately in the sense of Du Rietz (1930, Svenska Botanisk Tidsskrift, **24**: 333–428), i.e., a population forming an important and distinct regional aspect or facies of a species. Populations differing from the typical form in one or a few relatively minor characters and constituting a rather local facies of the species are termed *varieties*.

The writer has no complaint against the description and naming of every morphological unit or phase capable of being definitely described, but on the contrary favors it, for only by recording the multitude of forms encountered can our knowledge of the genus be advanced. However, the designation of all such forms, many of them extremely local and clearly referable to established species, as species, without reference to their obvious relationships within the genus, exaggerates their relative importance. The writer has attempted to place such forms in their proper positions of relationship even though this involves the making of several new combinations. It has seemed desirable in the present instance to include as unnumbered species certain recently described forms. For the most part these forms are insufficiently known. The diagnoses appear in the taxonomic arrangement immediately following the species to which they appear to be most closely related. Minor variants which occur sporadically are described but not named.

GEOGRAPHICAL DISTRIBUTION

The genus is almost wholly western North American. One species, *A. uva-ursi*, is almost circumpolar, being widely spread through middle and northern Europe, eastern Siberia, Alaska, Canada, and into the United States along the Pacific and Atlantic coasts and the higher mountains. The greatest concentration of species occurs within the areas termed by Fenneman (1931, Physiography of Western U. S.) the Sierra-Cascade, and the Pacific Border provinces. A weak eastward extension occurs into Nevada, Arizona and Colorado, thence southward through the Mexican highlands.

GEOLOGICAL RECORD

The geological record of *Arctostaphylos* is discussed by Mason (51) in connection with the reporting of remains of two species in the Pleistocene of the Tomales Region. The oldest fossils of undoubted *Arcto-*

staphylos come from the lower Pliocene Clarendon beds of Texas. From the great abundance of *Arctostaphylos* material in southern California, in the Carpenteria Asphalt of Santa Barbara County and in the Willow Creek flora on Santa Cruz Island, and its relative scarcity in the Pleistocene flora of Tomales, Mason concludes that the Pleistocene center of distribution and variation was in southern California, and that the center has moved northward and is now in the central and northern coastal region of California. The relatively greater stabilization of the southern forms, especially among the root-crown sprouters, and the conspicuous instability in the region north of San Francisco would also seem to point to a southern center of distribution moving northward. From the absence of records of *A. uva-ursi* in the Pliocene and Pleistocene outside of North America, Mason suggests a North American origin for that species, with a post-pleistocene circumpolar distribution.

Grateful acknowledgement is made of invaluable assistance from Dr. Willis Linn Jepson with whose advice and encouragement the study was begun; from Dr. Herbert L. Mason who arranged for the loan of type specimens and other materials from various herbaria; and from Miss Alice Eastwood who placed at the author's disposal type specimens and collections deposited in the Herbarium of the California Academy of Sciences.

The location of certain cited specimens may be identified as follows:

UC	University of California
CA	California Academy of Sciences
SU	Dudley Herbarium, Stanford University
UO	University of Oregon, Eugene
WU	Willamette University, Salem, Oregon
US	United States National Herbarium
NY	New York Botanical Garden
G	Gray Herbarium, Harvard University
J	W. L. Jepson
A	J. E. Adams

A set of the author's *Arctostaphylos* material is deposited in the Herbarium of the University of California.

From the several thousands of herbarium specimens examined, a few have been selected for citation under each species, upon the following grounds:—(1) Critical specimens, (2) Specimens of historical importance, (3) Representatives of widely distributed collections, (4) Specimens of importance in establishing limits of range. These have been arranged by state and county in the cases of widely spread species, or in a definite geographical sequence in species of narrower range. Locali-

ties are given first, followed by the name of the collector and his number (or date of collection when unnumbered).

TAXONOMIC TREATMENT

ARCTOSTAPHYLOS Adanson. Fam. Pl. **2:** 165 (1763)

Uva Ursi (Tourn.) Mill. Gard. Dict. Abr. ed. 4 (1754).
Mairania Neck. Elem. Bot. **1:** 219 (1790).
Xerobotrys Nutt. Trans. Am. Phil. Soc. II, **8:** 267 (1843).
Daphnidostaphylis Klotzsch, Linnaea **24:** 79 (1851).
Schizococcus Eastw. Leafl. West. Bot. **1:** 98 (1934).

Low prostrate, procumbent or erect shrubs, or small trees with smooth crooked branches, the thin dark red or chocolate colored bark promptly exfoliating in thin plates or curls, or these sometimes persistent and the surface shreddy or fibrous. Leaves alternate, evergreen, coriaceous, entire or sometimes serrate, petiolate or sessile, usually borne vertically. Inflorescence a terminal panicle, cluster of racemes or occasionally a single raceme with white or pink flowers on slender pedicels subtended by small foliaceous or scale-like bracts. Flower 5-merous (rarely 4-); sepals distinct, persistent; corolla urceolate with short rounded recurved lobes; stamens twice number of corolla lobes, included, with filaments dilated and usually hairy at base, and with dark red anthers bearing two recurved dorsal awns; ovary seated on an hypogynous disc, 4- to 10-celled, with a single ovule in each cell. Fruit brown or dark red, berry-like with copious dry granular, mealy or leathery pericarp, or rarely with thin pericarp and then greenish, enclosing 4 to 10 1-seeded nutlets, or these may be variously fused in 2's or 3's or sometimes coalesced into a single solid stone. The root crown of many species becomes greatly enlarged, and under the influence of recurrent fires, forms massive tabular platforms or globose structures near the surface of the ground, from which numerous sprouts arise after destruction of the above-ground portion by fire or mutilation.

KEY TO THE SPECIES AND SUBSPECIES

A. Ovary glabrous (except occasionally in No. 15; see Nos. 18, 20, and var. of No. 16) or viscid-glandular

Prostrate, procumbent or low mound-forming shrubs.
  Pedicels pubescent and glandular; leaves thick, veiny; petioles stout, flat; Guatemala ..... 1. *A. cratericola*
  Pedicels glabrous (rarely sparsely pubescent in No. 2), petioles terete.
    Leaves broadest above the middle.
      Bark smooth; leaf apex shortly acute, mucronate-cuspidate; montane ..... 2. *A. nevadensis*
      Bark rough or shreddy.

Leaves glabrous above and below, apex rounded; coastal
3. *A. uva-ursi*
Leaves tomentulose and pale below, apex obtuse or acute, apiculate; Monterey....4. *A. pumila*
Leaves broadest at or below the middle.
Compact mound-like colonies; panicle small, few-flowered; bark reddish purple; Monterey....5. *A. hookeri*
Loose, sprawling; panicle many-flowered; bark blackish; Sonoma Co.
6. *A. densiflora*

Erect shrubs 1 to 3 (or 6) m. high, sometimes arborescent.
Leaves bright green (somewhat glaucous in No. 13); pedicels glabrous.
Branchlets and rachises essentially glabrous or minutely glandular.
Bracts small, deltoid, scale-like, keeled.
Panicles loose, much branched, elongated, delicate.
Fruit asymmetrical; branchlets glabrous..7. *A. stanfordiana*
Fruit symmetrical; branchlets minutely glandular-hispidulous....7a. subsp. *hispidula*
Panicles little branched; rachises and branchlets coarser, minutely glandular-hispidulous....7b. subsp. *bakeri*
Bracts more or less foliaceous, ovate or lanceolate.
Fruit glabrous, not viscid; sprouting from enlarged root-crown; Sierra Nevada.
Panicle very dense, broadly corymbose; peduncles and rachises greenish glandular; fruit 8–10 mm. broad
12. *A. patula*
Panicle open; branchlets and rachises glabrate, glaucous; fruit 12 mm. broad, deeply umbilicate....13. *A. mewukka*
Fruit viscid-glandular, 8–10 mm. broad; no enlarged root-crown
8. *A. elegans*
Branchlets and rachises mostly canescently pubescent, non-glandular.
Rachises uniform; bracts remote.
Nutlets free; compact shrub 2–6 m. high, often arborescent
9. *A. manzanita*
Nutlets coalesced into single ribbed stone; diffuse shrub; Tehachapi Mts....10. *A. parryana*
Rachises thickened upwards; bracts proximate; leaves ovate to elliptic, pungent....11. *A. pungens*
Leaves pallid-glaucous; pedicels glandular-hairy.
Pericarp leathery; stone solid; bracts foliaceous, lanceolate, spreading
14. *A. glauca*
Pericarp mealy, copious; nutlets separable; bracts inconspicuous, scale-like....15. *A. viscida*

B. Ovary pubescent or glandular-hairy (except No. 20, var. of No. 16, and occasionally in No. 18)

Pericarp thick, granular or mealy (except No. 18).
Foliage very pallid or dull grayish green (except var. of No. 16 and of No. 20; see No. 24 and var. of No. 28).

Leaves petiolate.
Branchlets glandular-hairy; ovary and fruit glandular-hairy.
Bracts inconspicuous, ovate, persistent; panicle dense, small, many-flowered....16. *A. mariposa*
Bracts small but conspicuous, lanceolate, pink, membranaceous, deciduous; panicle large, openly branched....17. *A. pringlei*
Branchlets mostly canescently pubescent or villous, non-glandular; ovary and fruit essentially non-glandular.
Bark shreddy, fibrous; branchlets villous; corolla 3–5 mm. long; fruit 4–5 mm. broad; pericarp thin....18. *A. nissenana*
Bark smooth; branchlets canescent; corolla 8–9 mm. long; fruit dark red, 6–8 mm. broad....19. *A. canescens*
Leaves sessile or nearly so, more or less auriculate; ovary and fruit glabrous....20. *A. pechoensis*
Foliage bright green (except in No. 24 and var. of No. 28).
Leaves sessile, auriculate.
Bark on old stems smooth; crown openly or loosely branching 21. *A. andersonii*
Bark on old stems shreddy; crown dense, compact 22. *A. pajaroensis*
Leaves petiolate.
Leaf bases acute to obtuse.
Bracts small, deltoid, spreading; sepals conspicuously fimbriate....23. *A. insularis*
Bracts more or less foliaceous, erect.
Branchlets pubescent or puberulent, non-glandular.
Leaves oblong to obovate, ashy green; stems from an enlarged root-crown....24. *A. cinerea*
Leaves elliptical to oval, bright green; no enlarged root-crown....25. *A. parvifolia*
Branchlets more or less glandular-hairy (except vars. of No. 28).
Leaves noticeably thin; no enlarged root-crown; inflorescence glandular.
Branchlets coarse (3–4 mm. thick), white setose (except var.)....26. *A. columbiana*
Branchlets slender (2 mm. thick), short dark glandular-hairy, non-setose; Marin Co.. 27. *A. virgata*
Leaves thickish; sprouting from extensive woody root-crown....28. *A. glandulosa*
Leaf bases truncate or subcordate; leaves thickish.
Bark smooth; branchlets essentially non-glandular 29. *A. crustacea*
Bark conspicuously persistent-shreddy.
Branchlets densely tomentose; pedicels villous, non-glandular....30. *A. tomentosa*
Branchlets very glandular-hairy; pedicels glandular-hairy 30b. subsp. *bracteosa*

Pericarp very thin; fruit about 4 mm. long, greenish, separating into 2 to 5 one-seeded nutlets.
Flower parts in 4's.
Mat-like or mound-forming shrub, diffusely branching; fruit globular, 5-seeded.....31. *A. nummularia*
Erect, 1–2 m., compact; fruit laterally flattened, 2-seeded
32. *A. sensitiva*
Flower parts in 5's; bark with a conspicuous waxy bloom; Amador Co.
33. *A. myrtifolia*

1. **Arctostaphylos cratericola** Donn. Sm. Bot. Gaz. **55:** 437 (1913).
Arctostaphylos pungens var. *cratericola* Donn. Sm. Bot. Gaz. **16:** 13 (1891).

Prostrate, caespitose, densely leafy shrub with dark brown scaly bark; branchlets stout, puberulent or glabrate; leaves bright green, shining, glabrous, thick, suborbicular to broadly oval or broadly obovate; apex rounded or subacute, with callose tip, base acute or obtuse, conspicuously veiny, 1–1.75 cm. long, on short (2 mm.), stout, flat petioles; inflorescence short, dense, almost sessile raceme, bracts lanceolate, thickish, puberulent or glabrous, spreading; pedicels puberulent and somewhat glandular; calyx rosy, ciliate; corolla white with rose-tinged lobes, 4–6 mm. long; ovary glabrous. Fruit unknown.

Type locality: Volcan de Agua, Guatemala, on rocks in crater, 12,000 ft., *J. Donnell Smith 2159*, Apr. 1890 (US).

Range: Apparently restricted to the type locality.

Representative Specimens: Volcan de Agua, Dep't Zacatepequez, Guatemala, 12,000 ft., *J. D. Smith 2159*, Type, (US, also NY); 9,000 ft., *Kellermann 4754* (US); *Kellermann 7226* (NY); 8,000 ft., *Kellermann 4950* (US); *Maxon & Hay 3698* (US).

This species is distinctive in aspect, quite different from any of its congeners in Mexico. The foliage is somewhat reminiscent of the prostrate *A. uva-ursi*, or of *A. hookeri* of California.

2. **Arctostaphylos nevadensis** Gray, Syn. Fl. **2**[1]**:** 27 (1878).
Arctostaphylos pungens variety Gray, Bot. Calif. **1:** 453 (1876).

Low, often mat-like shrub with procumbent, intricately branching stems rooting freely in contact with the soil, erect branchlets rising up to 6 dm.; bark of stems smooth, brownish or deep red, exfoliating in irregular flattish scales; branchlets with conspicuous gray puberulence, becoming somewhat viscid with age; leaves bright green, glabrous or sparsely puberulent, varying in shape from narrowly lanceolate or elliptical to oblanceolate, oval or broadly obovate, with obtuse, or more

commonly acute and mucronate-cuspidate apex, and acute base, 2–2.5 or even 3.5 cm. long, on stout puberulent petioles 5 mm. long; inflorescence compact, many-flowered, erect, with peduncle and rachises puberulent; bracts small, deltoid-acuminate, the lowest usually foliaceous; pedicels 2–5 or 6 mm. long, mostly glabrous, but often moderately white hairy; corolla white or pinkish, about 5 mm. long; ovary glabrous, with nutlets variously separable or occasionally completely fused into a single stone and enclosed in moderately thick granular pulp.

Type locality: Sierra Nevada of California, 8,000 to 10,000 ft.

Range: Mountain ridges and slopes, mostly in open pine forest. Sierra Nevada of California from Tulare Co. northward, through the Cascade Range into central Washington; North Coast Ranges from northern Lake Co. to Siskiyou Co., Calif. and northward to Rogue Riv., Ore., at altitudes of 6,000 to 10,000 ft., or sometimes as low as 4,000 ft.; western Nevada and probably eastward on high mountains.

Representative Specimens: CALIFORNIA. Tulare Co.: Trail, Eagle Lake to Mineral King, *Bracelin 732* (UC). Fresno Co.: Dinky Cr., *Hall & Chandler 414* (UC). Tuolumne Co.: Yosemite, *King* (UC). Amador Co.: Peddlers Hill, *Adams 512* (UC). Eldorado Co.: Susie Lake, *Wolf*, Rancho Sta. Ana Herb. *1720* (UC). Nevada Co.: Summit, *Jepson 14719* (J). Butte Co.: Jonesville, *E. B. Copeland*, Dist. Herb. U. C. *672, 672a.* Plumas Co.: Silver Lake, *Adams 817* (UC). Shasta Co.: Mt. Lassen, *Copeland* in 1931 (UC). Modoc Co.: Davis Cr., Warner Mts., *Goldsmith* (UC). Siskiyou Co.: Klamathon, *E. B. Copeland*, Dist. C. F. Baker *3520;* Marble Mt., *Chandler 1598* (UC). Lake Co.: Mt. Hull, *Mackie* in 1902 (UC). Tehama Co.: Yollo Bolly Mt., *Taylor* in 1913 (UC). Humboldt Co.: Trinity Summit, *Jepson 2047* (J). Del Norte Co.: French Hill, *Eastwood 12217* (CA). OREGON. Klamath Co.: Crater Lake, *Heller 13042* (NY). Deschutes Co.: Mackenzie Pass, *Benson 2240* (NY). Crook Co.: Grizzly Butte, *Leiberg 248* (NY). Mt. Hood, *Thos. Howell* in 1880 (NY). WASHINGTON. Kittitas Co.: Valley of Swauk Riv., *Sharples 177* (NY). Chelan Co.: Mt. Stuart, *Sandberg & Leiberg 548* (NY).

ARCTOSTAPHYLOS COLORADENSIS Rollins, Rhodora **39:** 463 (1937). Type locality 3 miles west of Cold Spring Ranger Station, Uncompahgre Plateau, Mesa Co., Colorado, *Rollins 1587* (G). "Shrub 3–6 dm. high, forming dense beds 3–10 m. in diameter; stems spreading or decumbent, 1–2 cm. in diameter toward base, intricately and irregularly branched; exfoliating bark dark red, glabrous; branchlets and petioles glandular-puberulent; leaves erect, divergent or often pendulous, obo-

vate, not cuspidate-mucronate, glabrous or minutely glandular toward base; blades 2–3 cm. long, 1–1.5 cm. wide; petioles 4–7 mm. long; inflorescence congested-paniculate; bracts and rachis glandular-puberulent; bracts lanceolate-attenuate, the lower foliaceous, oblong and acute; pedicels glabrous, 2–4 mm. long; sepals orbicular, scarious margined; berry globose, bright red when mature; nutlets roughened, single-ribbed dorsally, more or less coalescent; flowers unknown."—Known only from the type collection. The chief differences from *A. nevadensis* Gray are the somewhat larger, non-cuspidate leaves and a tendency to a more upright growth habit. Type seen.

3. **Arctostaphylos uva-ursi** (L.) Spreng. Syst. Veg. **2:** 287 (1825).

Arbutus uva-ursi L. Sp. Pl. 395 (1753). *Uva-ursi procumbens* Moench, Meth. 470 (1794). *Mairania Uva-ursi* Desv. Jour. Bot. Desv. II, **1:** 38 (1813). *Uva ursi buxifolia* S. F. Gray, Nat. Arr. Brit. Pl. **2:** 400 (1821). *Arctostaphylos officinalis* Wimm. & Grabb. Fl. Siles. **1:** 391 (1827). *Arctostaphylos procumbens* Patze, Meyer & Elkan, Fl. Preuss. 188 (1850). *Daphnidostaphylis Fendleriana* Klotzsch, Linnaea **24:** 80 (1851). *Arctostaphylos Uva-ursi alba* Cockerell, W. Am. Sci. **6:** 11 (1889). *Uva-ursi Uva-ursi* (L.) Britton, Britt. & Brown, Ill. Fl. ed. 2, **2:** 693 (1913).

Prostrate shrub with several trailing stems and erect branches up to 15 cm. long; bark rough and shreddy; branchlets clothed with a light, more or less persistent tomentulum, or viscid-villous pubescence; leaves oval or obovate, rounded or subacute at apex, cuneate at base, glabrous and shining, 1–2.5 cm. long, 5–10 mm. wide; inflorescence a dense short cluster with pubescent or glabrate rachises and small bracts; pedicels glabrous; corolla white or pinkish, 4 or 5 mm. long; ovary glabrous; fruit bright red, smooth, 6–8 mm. broad with separable nutlets.

Type loc.: "Europa frigida et Canada."

Range: This species, the most widely distributed of the genus, occurs in three geographic forms. The typical form, with rather promptly deciduous tomentulum, is found in northern latitudes of the eastern hemisphere and in the western hemisphere from Greenland to Newfoundland and Quebec, and from the Bering Sea southward to the Black Hills and New Mexico and to Washington. A form described as var. *coactilis* Fern. & McBr. Rhod. **16:** 212 (1914), type loc. Brunswick, Me., *Chamberlain*, has a persistent non-glandular tomentulum, occurs from Newfoundland to Yukon, south to Virginia, Indiana, Illinois, in the mountains to Colorado, and along the coast into northern California.

Variety *adenotricha* Fern. & McBr., l.c., type loc. Golden, B. C., *Batchelder*, with viscid-villous pubescence of branchlets and petioles, the pubescence mixed with black glands, has the smallest range, extending from Quebec to Saskatchewan, British Columbia, Montana and Colorado.

Representative Specimens: Typical. UTAH: Fish Lake, *M. E. Jones 5711.* WYOMING: Sheep Mt., Albany Co., *Goodding 24094.* COLORADO: Boulder Co., *W. W. Robbins 1764.* ALBERTA: Sarcee Reserve, *P. E. Goddard 447.* SWEDEN: Vancesborg, *K. Rahne* in 1911. FINLAND: Stor Birkholm, Lorkka, *H. Hollmen* in 1879. SIBERIA: Prov. Irkutsk. JAPAN: Southern Hokkaido, *W. P. Brooks 726.*

Var. *coactilis.* CALIFORNIA: Inverness Ridge, Marin Co., *Ewan 8086;* McNamee's, Sonoma Co., *Adams 829;* Humboldt Bay, *C. B. Wolf*, Rancho Sta. Ana Herb. *1779;* Lake Earl, Del Norte Co., *Davy* in 1907. OREGON: Coos Bay, *Green* in 1930; Yaquin Bay, *Chestnut.* WASHINGTON: Hangman Cr., Spokane Co., *Sandberg & Leiberg 69.* BRITISH COLUMBIA: Langford, *Pineo* in 1896. YUKON: *MacLean* in 1898. MONTANA: Bozeman, *J. W. Blankinship.* MICHIGAN: Grand Island, *Pettit 10652.* MAINE: Bayville, *Grover* in 1911. MASSACHUSETTS: Arlington, *S. C. Brooks 1172.*

Var. *adenotricha.* COLORADO: Hot Sulphur Springs, *Ramaley & Robbins 36–22.* MINNESOTA: Clearwater Co., *Grant 3167.* (All UC.) ALBERTA: Lake Louise, Bow Riv., *J. T. Howell 7832.* BRITISH COLUMBIA: Kicking Horse Riv., at Field, *J. T. Howell 7823.* WASHINGTON: Sheep Mt., *J. T. Howell & W. P. Taylor* in 1920. (All CA.)

In various regions on the Pacific Coast this species appears to have hybridized with several of its congeners, giving rise to local forms of various aspect. One of these local hybrid forms was described from Mason Co., Washington, as *A. media* Greene, Pitt. **2:** 171 (1891), which has leaves rather larger than those of *A. uva-ursi* and somewhat puberulent. Others occur at points on the Mendocino and Sonoma County, California, coast, in which the subhispid stems indicate an origin from *A. columbiana.* The writer has collected in this area a form which in leaf characters appears quite intermediate between *A. uva-ursi* and *A. nummularia* (*Adams* 823).

4. **Arctostaphylos pumila** Nutt. Trans. Am. Phil. Soc. ser. 2, **8:** 266 (1843).

Daphnidostaphylis pumila Klotzsch, Linnaea **24:** 267 (1851).

Low mat-forming shrub with ascending branches and rather shreddy bark; branchlets pubescent or downy; leaves dull green or semi-shining

and glabrous above, pubescent or somewhat tomentulose below, obovate, variable in size but averaging 1.5–2 cm. long and 8 mm. wide, apex obtuse or short-acute and apiculate; inflorescence a short dense raceme with pubescent rachis and small lanceolate or acuminate bracts; pedicels usually sparsely pubescent; corolla white, 4 mm. long; ovary glabrous; fruit glabrous, 5 mm. broad, with separable nutlets.

Type locality: Monterey, California, *Nuttall.*

Range: Central coastal California; sandy hills bordering Monterey Bay; San Francisco.

Representative Specimens: CALIFORNIA. Del Monte, *Heller 6493* (UC); Monterey, *Eastwood*, Dist. C. F. Baker *3173;* Seaside, *Adams 693* (UC); Masonic Cemetery, San Francisco, *Kellogg & Harford 70* (UC).

5. **Arctostaphylos hookeri** Don, Gen. Syst. **3:** 836 (1834).

Andromeda venulosa DC. Prod. **7:** 607 (1839), type loc. "Nova California," *Douglas. Arctostaphylos acuta* Nutt. Trans. Am. Phil. Soc. ser. 2, **8:** 267 (1843), type loc. Monterey, *Nuttall. Xerobotrys venulosa* Nutt. Trans. Am. Phil. Soc. ser. 2, **8:** 268 (1843). *Daphnidostaphylis hookeri* Klotzsch, Linnaea **24:** 80 (1851). *Arctostaphylos Franciscana* Eastw. Bull. Torr. Club **32:** 201 (1905), type loc. Laurel Hill, San Francisco, *Eastwood.*

Low erect or procumbent shrub forming rounded mounds 1.5 dm. to 1 m. high, the lateral branches rooting where touching the soil; bark smooth, deep purplish brown; branchlets pubescent or minutely canescent near tips; leaves bright green, shining, glabrous, thin, ovate to elliptic, short-acute, mucronate, 1.5–2.5 cm. long, 1–1.5 cm. wide; inflorescence small, compact, few-flowered; bracts small, acuminate; pedicels glabrous; corolla white to pinkish, 4 mm. long; ovary glabrous; fruit bright red and glossy, averaging 6 mm. broad.

Type locality: Monterey, California, *Lay & Collie.*

Range: Central coastal California: sandy hills and ridges, 20 to 400 ft. Northern Monterey Co.; San Francisco.

Representative Specimens: CALIFORNIA. Cypress Point, Monterey, *Wolf*, Rancho Sta. Ana Herb. *1815;* Carmel Bay, *Elmer 4078* (UC); Carmel Hills, *Adams 709* (UC); Pacific Grove, *Heller 6474* (UC); Pajaro Hill, Monterey Co., *Adams 913* (UC); San Francisco, Laurel Hill, *Eastwood 11072* (CA).

6. **Arctostaphylos densiflora** Baker, Leafl. West. Bot. **1:** 31 (1932).

Low, loosely spreading and freely rooting shrub with rather slender crooked and blackish branches; branchlets with fine pubescence; leaves

bright green, shining, smooth, mostly elliptical, obtuse or acute and mucronate at apex, base cuneate, 1.5–3 cm. long, 1–1.5 cm. wide; inflorescence a short dense many-flowered panicle with appressed-pubescent rachises and small ovate-acuminate bracts; pedicels slender, glabrous; corolla rosy or white, 4–5 mm. long; fruit flattened-globular, smooth, 5–6 mm. broad, with separable nutlets.

Type locality: Vine Hill School, near Santa Rosa, Sonoma Co., California, *M. S. Baker 5045* (CA).

Range: Known only from the type locality where it forms a loose carpet over roadside banks.

Representative Specimens: Vine Hill School, *M. S. Baker 5045*, Type (CA); *Baker 3882* (UC); Frei Ranch, Vine Hill, *Adams 1032* (UC).

This species apparently hybridizes freely with *A. manzanita* in the region, and with *A. stanfordiana*, producing a bewildering series of intergrades. In this and adjacent areas *A. stanfordiana*, to which this species appears closely related, is a depressed shrub, often cascading over road banks, but apparently not rooting where branches touch the soil as does *A. densiflora*.

7. **Arctostaphylos stanfordiana** Parry, Bull. Cal. Acad. **2:** 493 (1887).

Erect trim shrub 1.5 to 2.5 m. high with long, slender, dark red, glabrous or minutely puberulent branchlets; leaves bright green and shining, mostly oblanceolate or narrowly ovate, acute at apex and base, 3–6 cm. long, borne quite erect; inflorescence a delicate elongated panicle with very slender, reddish, glabrous or minutely puberulent rachises, and very small scale-like bracts conspicuously keeled; pedicels glabrous; corolla whitish pink or rosy, mostly 4–5 mm. long, narrowly urceolate with closely appressed sepals; ovary glabrous; fruits bright red, glabrous, commonly asymmetrical, 5–7 mm. broad, with variously separable, lightly ridged nutlets. The shrub produces no enlarged root-crown and is completely killed by fire.

Type locality: Calistoga, Napa Co., California, *Parry*.

Range: Common in Napa, Sonoma, Lake, and Mendocino counties, California, on mountain summits and open ridges, 1000 to 4000 ft.

Representative Specimens: CALIFORNIA. Napa Co.: Calistoga, *C. C. Parry* in 1888 (UC); between Franz Valley and Calistoga, *Wiggins 5768* (UC, SU); Mt. St. Helena, *Adams 649* (UC). Lake Co.: Howell Mt., *Jepson 6586* (J); Bartlett Mt., *Eastwood* in 1900 (UC); Kelseyville, 10 mi. s. of, *Adams 659* (UC). Sonoma Co.: Rincon Ridge, e. of Sta. Rosa, *Adams 1021* (UC). Mendocino Co.: Red Mt., *Eastwood* in 1901 (UC); Gould Ranch, s.w. of Ukiah, *Jepson 7629* (J, SU).

In the Vine Hill and Rincon Ridge areas near Santa Rosa, Sonoma Co., this species becomes a much depressed shrub, often cascading over road banks. (*Adams 1021.*) It hybridizes with *A. manzanita*, producing individuals difficult of assignment to one or the other form. The long slender rachises and small remote and keeled bracts, however, appear to be constant and serve to distinguish this species from *A. manzanita*.

7a. **Arctostaphylos stanfordiana** subsp. **hispidula** (Howell) n. comb.

Arctostaphylos hispidula Howell, Fl. Nw. Am. 415 (1901). *Arctostaphylos viscosissima* Peck, Torreya **32:** 151 (1932), type loc. Bald Mt., Curry Co., Ore., *M. E. Peck 8974* (WU).

Erect, straight-branching shrub, 1 to 2 m. high; stems with smooth, very dark or almost blackish bark; branchlets slender, dark, clothed with a close viscid puberulence and conspicuous hispidulous glandular hairs; leaves light green, semi-shining, somewhat scabrous with scattered short rigid glandular hairs, elliptic, 3–3.5 cm. long, 1.5 cm. wide, acute at base and apex, apiculate, on puberulent and glandular-hairy petioles 5–7 mm. long; inflorescence ample, loose, with slender, somewhat glandular hairy rachises; bracts small, ovate-acuminate, keeled, glabrous or slightly puberulent; pedicels glabrous, slender, 5–6 mm. long; corolla white or pink, 5 mm. long; ovary glabrous; fruit globose, symmetrical, glabrous. The plants are killed outright by fire.

Type locality: Near Gasquet, Del Norte Co., California, *Howell* in April 1886 (UO).

Range: Northern Del Norte Co., California, and southern Curry Co., Oregon, in open woods or on exposed summits.

Representative Specimens: CALIFORNIA. Del Norte Co.: Adams Station, *Eastwood 15075* (UC, CA); Gasquet, *Adams 1058* (UC); *Thos. Howell* in 1886, type of *A. hispidula* Howell (UO). OREGON. Curry Co.: 5 mi. e. mouth Euchre Cr., dry summit of Bald Mt., *M. E. Peck 8974*, type of *A. viscosissima* Peck (WU).

Subspecies *hispidula* differs from the species chiefly in its glandular-hispidulous branchlets, smaller, roughish leaves, and symmetrical fruits.

7b. **Arctostaphylos stanfordiana** subsp. **bakeri** (Eastw.) n. comb.

Arctostaphylos bakeri Eastw., Leafl. West. Bot. **1:** 115 (1934).

Erect bushy shrub, 1 to 3 m. high, occasionally with old branches decumbent; stems with very dark, almost blackish purple smooth bark; branchlets coarser than in preceding, dark, with a close viscid puberulence and conspicuous hispidulous glandular hairs; leaves light green,

dullish, slightly scabrous with short rigid glandular hairs, elliptic, 3–3.5 cm. long, 1.5 cm. wide, apiculate, on glandular hispidulous petioles; inflorescence a loose terminal panicle with somewhat glandular-hairy rachises; bracts small, slightly keeled, hispidulous; pedicels slender, glabrous, 5–6 mm. long; corolla white or pink, 6 mm. long; ovary glabrous, fruit flattened-globose, symmetrical, glabrous. The plants produce no enlarged root-crown.

Type locality: Ridge 2 mi. e. of Occidental, Sonoma Co., California, *J. T. Howell 10955* (flowering), *10957* (fruiting) (CA).

Range: Southern Sonoma Co., Calif., on tops of ridges.

Representative Specimens: Occidental (ridge, 2 mi. e. of), Sonoma Co., *Adams 1026, 1031* (UC); Camp Meeker, Sonoma Co., *Adams 857* (UC).

8. **Arctostaphylos elegans** Jepson, Erythea **1:** 15 (1893).

Erect, trim shrub with straightish, smooth branches, 1 to 2 or up to 3.5 m. high; brachlets thickish, puberulent or glabrate; leaves bright green, dullish, glabrous, thick, and conspicuously veiny, mostly broadly ovate or elliptic with obtuse base and acute or obtuse apex, 3–7 cm. long, 2–4 cm. wide; inflorescence with thickish pubescent rachises and deltoid-ovate spreading bracts 3–4 mm. long; pedicels glabrous; corolla white, 7–8 mm. long; sepals closely appressed; ovary glandular; fruit dark red, stipitate-glandular, 8–10 mm. broad with variously separable nutlets. No enlarged root-crown is produced; the shrubs are killed outright by fire.

Type locality: Obsidian slopes south of Mt. Konocti, Lake Co., California, *Jepson 14729* (J).

Range: Montane (chiefly obsidian) slopes, 1000 to 4000 ft., Lake Co., Calif.

Representative Specimens: CALIFORNIA. Mt. St. Helena, *Eastwood 11301* (UC, CA); s. of Mt. Konocti, *Jepson 14729*, type (J); Kelseyville, *Adams 844;* Snow Mt., *M. S. Baker 3127b* (UC).

This species is closely related to *A. manzanita* and the disposition of branchlets is suggestive of *A. stanfordiana.* The glandular ovary, very large glandular fruit, thickish branchlets and leaves, the latter conspicuously veiny, are distinctive features.

9. **Arctostaphylos manzanita** Parry, Bull. Cal. Acad. **2:** 491 (1887).

Arctostaphylos manzanita var. *apiculata* Jepson, Madroño **1:** 83 (1922), type loc. Weldon Canyon, Solano Co., *Jepson 7198* (J).

Erect shrub 2 to 4.5 m. high (or even 7.5 m.) with crooked branches widely spreading; bark smooth, dark red; branchlets typically clothed with dense canescent pubescence or tomentulum, or commonly only faintly puberulent; leaves bright green, dull or somewhat shining, glabrous above and below, or lightly puberulent, thick, broad-elliptic or oblong, subacute or obtuse at apex, occasionally apiculatish, obtuse or acute at base, averaging 2.5 cm. long; inflorescence an ample drooping panicle with pubescent rachises and short-deltoid acute bracts 2 mm. long; pedicels glabrous; sepals closely appressed to corolla; corolla white or pink, usually 5–7 mm. long, narrowly urceolate; ovary typically glabrous or occasionally somewhat pubescent, non-glandular; fruit deep red, smooth, 8–10 mm. broad, with variously separable ridged nutlets. The shrubs produce no enlarged root-crown, but are completely killed by fire.

Type locality: Napa Range near Calistoga, California, *Parry*.

Range: Chiefly rocky hill slopes and canyons, 300 to 2500 (or 4000) ft. North Coast Ranges of California, mostly toward the interior, Napa to Shasta counties; thence southward in the Sierra Nevada foothills to Tuolumne Co., Calif.

Representative Specimens: CALIFORNIA. Napa Co.: Mt. St. Helena, *Adams 643* (UC); *Jepson 14714* (J). Sonoma Co.: Seaview, on Cazadero Rd., *Adams 729* (UC); Santa Rosa, *Meyer 303* (UC); Hills bet. Knights and Franz valleys, *Wiggins 5762* (UC, S). Solano Co.: Vacaville, *Jepson* in 1885 (J); Weldon Canyon, *Jepson 7198*, type of var. *apiculata* (J). Lake Co.: Elk Mt., *Tracy 2352* (UC, CA); Howell Mt., *Jepson 5319* (J); Mt. Konocti, *Adams 582* (UC). Mendocino Co.: Osbornes, Forest Res., *Eastwood 15235* (UC, CA); Long Valley, *Tracy 6621* (UC, CA, J); Castle Peak, *Jepson 14707* (dup. No.) (J); Summit bet. Booneville and Ukiah, *Adams 590* (UC). Humboldt Co.: S. Fork Eel Riv., near Mendocino line, *Tracy 5056* (UC); Trinity Riv., mouth Willow Cr., *Tracy* (UC). Tehama Co.: Red Bluff, *Herman*, Dist. C. F. Baker *3170*. Shasta Co.: Redding, *Heller 7872* (UC). Butte Co.: Big Chico Cr., e. of Chico, *Heller 11152* (UC). Yuba Co.: North Peak Marysville Buttes, *Keifer* in 1928 (UC). Amador Co.: Ione, *Adams 799* (UC). Calaveras Co.: Copperopolis, *Davy 1363* (UC).

Many individuals possessing the general aspect of this species vary in one or more details from the typical form. Thus pubescent ovaries and pedicels are occasionally encountered; shining leaves and almost glabrous branchlets, conspicuous in some plants, appear to be intermediate with *A. stanfordiana* which occurs in a portion of the range of

this species. It appears likely that hybridization is common among these forms.

ARCTOSTAPHYLOS LAEVIGATA Eastw. Leafl. West. Bot. **1:** 76 (1933). Type locality Mt. Diablo (half way up old road), *Eastwood 11082* (CA). Low bushy, intricately branched shrub; bark smooth, brownish red; branchlets finely pubescent; leaves shining, oblong to lanceolate; inflorescence drooping, with reddish, pubescent rachises; bracts small; pedicels glabrous; corolla white, 7 mm. long.—Mt. Diablo: Rock City, *Adams 682, 671* (UC); Head of Sycamore Cr., *Jepson 9736* (J). Mt. St. Helena, *Adams 646* (UC). Type seen. This plant presents interesting combinations of the characters of *A. stanfordiana* and *A. manzanita*. The leaves are of the *stanfordiana* type; branchlets and rachises are pubescent as in *A. manzanita*, possess the red coloration of *A. stanfordiana*, and approach those of *A. manzanita* in size; flowers average near the size of those of *A. manzanita;* fruits are bright red, intermediate in size, and usually rather asymmetrical. A possible hybrid origin is suggested. The absence of both suspected parents from Mt. Diablo and a rather long isolation might permit some stabilization of the form. A few individuals can be found on Mt. St. Helena where both *A. stanfordiana* and *A. manzanita* occur which are perfect matches for the Mt. Diablo form.

10. **Arctostaphylos parryana** Lemmon, Pitt. **2:** 68 (1890).

Diffuse, widely spreading shrub 1 to 2 m. high, with lateral branches commonly decumbent and rooting in contact with the soil; bark smooth, dark red; branchlets lightly pubescent or glabrate, greenish or red tinged; leaves bright green, somewhat shining, glabrous, thick and veiny, ovate, oval or sometimes obovatish, with acute to rounded apex, acute, obtuse or truncatish base, averaging 3 cm. long, 1.5 cm. wide, on stout petioles 1 cm. long; inflorescence few-flowered with long drooping peduncle, puberulent rachises, and short deltoid-acuminate bracts; pedicels long, glabrous; corolla white, about 7 mm. long; ovary glabrous; fruit dark red, glabrous, orbicular, averaging 8–10 mm. broad with a single fused, slightly ribbed stone. No enlarged root crown is produced. The plants spread widely by the rooting of the branches.

Type locality: Tehachapi Mts., near Keene Station, *Lemmon*, June 23 and August 5, 1888.

Range: Tehachapi Mts., south to San Gabriel and San Antonio Mts., Calif., 4000 to 7000 ft.

Representative Specimens: CALIFORNIA. Tehachapi Mts., Kern Co.,

4000 ft., *Lemmon*, June 1888 (UC); Mt. Pinos, 7000 ft., *Grinnell* (UC); south slope of Mt. Baldy, *Johnson 1468* (UC); San Antonio Canyon, San Antonio Mts., *Johnson 1575* (UC); Mt. Gleason, *Barber 265* (UC).

In general leaf shape and to some extent in the character of indument of branchlets this species resembles *A. manzanita*. However, the shrubs do not display the subarborescent habit of that species, but are spreading shrubs, branching from the base, the lateral branches often decumbent and rooting where they touch the soil. Many bushes become quite wide-spread in this manner, the colonies formed being generally circular in outline. The death of older plants in the colony thus leaves large circular formations of the newer growth (Wieslander). Foliage is lighter than in *A. manzanita* and the ultimate branchlets are on the whole somewhat straighter. The degree of coalescence of nutlets, variable in most of the other species is complete and constant in this.

11. **Arctostaphylos pungens** H. B. K. Nov. Gen. et Sp. **3:** 278 (1819). *Daphnidostaphylis pungens* Klotzsch, Linnaea **24:** 80 (1851). *Arctostaphylos montana* Eastw. Proc. Calif. Acad. ser. 3, **1:** 83 (1897), type loc. Mt. Tamalpais, Marin Co., Calif., *Eastwood*.

Erect shrub, 2 to 3 m. high, or low, 6 dm., and somewhat spreading; bark smooth, dark red; branchlets straightish, somewhat canescently pubescent or tomentose; leaves bright green, glabrous or minutely puberulent, oblong to elliptic or narrowly ovate, acute and pungent at apex, rounded or subacute at base, averaging 2 cm. long; inflorescence small and dense, the rachises thickened at tip; bracts short-deltoid, proximate, pubescent or tomentulose; pedicels glabrous; corolla white, 5 mm. long; ovary glabrous; fruit brownish red, globular or slightly irregular, smooth, 5–6 mm. broad. This species as observed in California produces no enlarged root-crown.

Type locality: Mexican plateau in vicinity of Mexico City, Mexico.

Range: Montane, almost throughout Mexico, Baja California; southern Texas to Nevada; southern California and through the inner South Coast Ranges to Mt. Tamalpais, Marin Co., Calif.

Representative Specimens: MEXICO: Cumbre de Talea, Oaxaca, *Reko 4049* (US); Mt. Orizaba, near Vera Cruz, *Purpus 2996* (UC, US); San Luis Tultitlanapa, Puebla, *Purpus 3250* (UC, US); San Luis de la Paz, Guanajuato, *Salazar* in 1913 (US); San Luis Potosi, *Schaffner 487* (UC, US); Etzatlan, Jalisco, *Barnes & Land 315* (US); Sierra de San Lorenzo, Nuevo Leon, *Pringle 13100* (US); Coahuila, *Nelson 6738* (US); El Salto, Durango, *Nelson 4560* (US); Mazatlan, Sinaloa, *Rose, Standley*

& Russell 13989 (US); Arroyo Ancho Guerrero, Chihuahua, *Mexia 2595* (UC); Cusihuiriachic, Chihuahua, *Rose 11660* (US); San Jose Mts., near Naco, Sonora, *Wolf 2531* (SU); Sierra Madre Mts., Int. bound. mon. #66, Sonora, *Wolf 2572* (SU). BAJA CALIFORNIA: 45 mi. s.e. Tecate Mt., *Munz 9529* (UC); Mountains, *C. R. Orcutt* in 1865 (UC); Northern District, *Cota* in 1932 (UC). ARIZONA: Prescott, *Nelson 10231* (UC); Coconino Forest, *Eastwood 15802* (UC, CA). TEXAS: Davis Mts., *Moore & Steyermark 3145* (UC). NEW MEXICO: Mogollon Mts., Mogollon Cr., *Metcalfe 270* (UC). UTAH: Anderson's Ranch, St. George, *Nelson 9994* (UC); Zion Nat. Park, *Eastwood & Howell 1172* (CA). NEVADA: Charleston Mts., *Purpus 6090* (UC). CALIFORNIA: Guatay, San Diego Co., *Adams 979* (UC); Campo, *Adams 978* (UC); Onstatt's Valley, San Jacinto Mts., *Hall* (UC); Hemet Valley, *Munz & Johnston 5491* (UC); Lake Arrowhead, San Bernardino Mts., *Lewis* (UC); La Panza Range, San Luis Obispo Co., *Johannsen* (J); The Indians, Monterey Co., *Wieslander* (J); Big Oak Flat, San Benito Co., *Wieslander* (J); Mt. Tamalpais, *Eastwood*, Dist. C. F. Baker *3996, 3165; Adams 507* (UC).

In some situations on Mt. Tamalpais *A. pungens* occurs as a low spreading shrub with the decumbent branches rooting in contact with the soil. Intergrades between this and the typical erect form are very numerous.

Some question may be raised as to the identity of the Californian plant with the plant of the type locality. Mr. Eric Walther, recently returned from Mexico where he collected at the type locality of *A. pungens*, reports (oral communication) that the shrub sprouts actively from the root-crown. The writer has seen his specimens which differ from those of California plants only in having thinner, longer, and somewhat more sharply pointed leaves. The inflorescence agrees in all respects with California specimens. At the type locality it occupies a good forest site, as an occasional member of the association, rather than as a dominant in an open chaparral site as with us. An abundance of Mexican material has been examined representing the plant from Sonora to Vera Cruz and Oaxaca. This material is indistinguishable from southern California specimens. It is possible, as frequently happens, that a layering of lateral branches has been mistaken for root-crown sprouting. Pending the acquisition of confirmative data on the matter of vegetative regeneration, the plant of California must be regarded as conspecific with the Mexican plant.

12. **Arctostaphylos patula** Greene, Pitt. **2:** 171 (1891).

Arctostaphylos glauca Wats. (not Lindl.), in King, Geol. Expl. 40th Par. **4:** 210 (1871), type loc. California. *Arctostaphylos pungens* var. *platyphylla* Gray, Syn. Fl. N. Am. **2**[1]**:** 28 (1878), type loc. California. *Arctostaphylos platyphylla* Kuntze, Rev. Gen. 385 (1891). *Arctostaphylos obtusifolia* Piper, Bull. Torr. Club **29:** 642 (1902), type loc. Black Butte, eastern Oregon, *Cusick 2688a*. *Arctostaphylos pinetorum* Rollins, Rhodora **39:** 462 (1937), type loc. 3 mi. w. of Cold Spring Ranger Station, Uncompahgre Plateau, Mesa Co., Colorado, *Rollins 1586* (G).

Erect shrub 1 to 2 m. high with several stout stems from an enlarged rounded root-crown, diffusely branching, usually with a symmetrical, rounded crown; bark chocolate colored, smooth; branchlets minutely glandular-puberulent, the glands yellowish green, or rarely the glandular-puberulence replaced by a simple light pubescence; leaves spreading or erect, bright green, thick, glabrous or minutely glandular at base, broadly ovate or broadly obovate to oblong or orbicular, 2.5–5.5 cm. (averaging 4 cm.) long, with rounded to obtuse or broadly acute apex, mostly rounded or truncate base, on stout, puberulent or minutely glandular petioles 6–10 mm. long; inflorescence a compact, corymbose or loosely spreading panicle with glandular-puberulent peduncle and rachises, the glands typically of a distinctive yellowish green color which darkens with age; bracts usually small, ovate-acuminate or lanceolate-acute, glandular-puberulent; pedicels glabrous, 2–6 mm. long; sepals broadly ovate with hyaline entire margin and rounded apex; corolla rose, 5–8 mm. long; ovary glabrous; fruit flattened-globose, 8–10 mm. broad, glabrous; nutlets variously separable, the parts smooth on back.

Type locality: Central Sierra Nevada, California.

Range: Open pine forests, 2000 to 5000 ft. (in the south to 9000 ft.). Inner North Coast Ranges from Lake Co. to Siskiyou Co.; Sierra Nevada from Shasta Co. to Tulare Co.; San Gabriel, San Bernardino, and San Jacinto Mts.; north to southern Oregon, east to Colorado, south into Baja California.

Representative Specimens: CALIFORNIA: Mt. Hull, Lake Co., *Hall 9567* (UC); South of Yollo Bolly, Tehama Co., *Jepson* (J); Trinity Summit, Humboldt Co., *Davy 5784* (UC); Siskiyou Mts., Siskiyou Co., *Thos. Howell 1448* (UC); Oregon Boundary, Del Norte Co., *Eastwood 12022* (CA); Diamond Mt., Lassen Co., *Faris* (UC); Susanville, *Jepson* (J); near Spanish Peak, Plumas Co., *Adams 816* (UC); Emerald Bay, Lake Tahoe, *Wiggins 5079* (UC, SU); Fallen Leaf Lake, Eldorado Co., *H. F. Copeland 1426* (UC); Donner Lake, Nevada Co., *Heller 7036*

(UC); Long Barn, Tuolumne Co., *Adams 529;* Yosemite Nat. Park, *Abrams 4496* (UC, SU); Mather, Tuolumne Co., *Munz 1380* (UC); Shaver Lake, Fresno Co., *Adams 788* (UC); Garfield Forest, S. Fk. Kaweah Riv., *Jepson 4664* (J); between Bear Valley and Sta. Ana Canyon, *Parish* (UC); Mill Cr., San Bernardino Mts., *Jepson 5589* (J); near Tahquitz, San Jacinto Mts., *Hall 2312* (UC); S. Fk. Sta. Ana, *Munz 6261* (UC). OREGON: McKenzie Bridge, Lane Co., *Constance 599* (UC); Black Butte, Crook Co., *Cusick 2816* (UC). BAJA CALIFORNIA: San Pedro Martir Mts., *T. S. Brandegee* in 1893 (UC). NEVADA: Franktown, *Heller 10393* (CA); Glenbrook, *C. F. Baker 1001* (UC). UTAH: Mineral Range, Beaver Co., *Gilbert* (UC); Bryce Canyon, near rim, *Eastwood & Howell 675* (CA); Zion Nat. Park, *Eastwood & Howell 1172a* (CA); Holiday Peak, Uinta Mts., *Clemens* (CA). COLORADO: Uncompahgre Plateau, Mesa Co., *Rollins 1586*, type of *A. pinetorum* (G).

Representatives of this species in the eastward extension beyond the Sierra Nevada of California show a gradual tendency to narrower and somewhat smaller leaves and a less compact and fewer-flowered inflorescence. The glandular puberulence regarded by Rollins as characteristic of the specimens from Colorado is typical of the Californian representatives of *A. patula* and offers no basis for distinction. However, there occurs infrequently with the typical form in the Sierra Nevada a form in which the glandular puberulence of rachises and peduncles is replaced by a light, simple pubescence. These are in complete agreement with the typical form in all other respects, including the presence of an enlarged root-crown.

As representative of the non-glandular, pubescent form we cite: California: Modoc Co., *M. S. Baker* (UC); Diamond Mt., Lassen Co., *Faris* (UC); Black Butte, Glenn Co., *Merriam* (UC); summit Peddlers Hill, Eldorado Co., *Adams 515* (UC); Sugar Pine, Tuolumne Co., *Adams 769* (UC); Long Barn, *Adams 763* (UC); Pine City, Mono Co., *K. Brandegee* (UC). Nevada: Ash Canyon, Ormsby Co., *C. F. Baker 979* (UC).

13. **Arctostaphylos mewukka** Merriam, Proc. Biol. Soc. Wash. **31:** 101 (1918).

Arctostaphylos pastillosa Jepson, Madroño **1:** 83, 93 (1922).

Erect shrub 1 to 2 m. high with open crooked branches arising from a rounded root-crown; bark very deep red or purplish, smooth; branchlets reddish, glabrous or sparsely pubescent, usually with a glaucous bloom;

leaves pale green, with a light bluish or grayish cast, glabrous, glaucous, 3–6 cm. long, varying greatly in shape from broadly elliptic or ovate to lanceolate or narrowly obovate, truncatish, rounded or acute at base, acute or sometimes rounded at apex, usually with a short mucro; petioles stout, 6–8 mm. long; inflorescence open, loose, half-drooping, with peduncle and rachises dark red, glabrous or puberulent, glaucous; bracts mostly foliaceous, the lower lanceolate, the upper shorter and acuminate; pedicels glabrous, 5–6 mm. long; corolla white or pinkish, 6 mm. long; ovary glabrous, or rarely very sparsely hairy at top; fruit large (12 mm. or more broad), orbicular or somewhat irregular, deeply umbilicate, glabrous, glossy, deep mahogany at maturity, with thick mealy pulp; nutlets variously separable or occasionally fused into a single ribbed stone. This species produces a heavy rounded root-crown from which sprouts arise after fire or mutilation.

Type locality: Ridge between N. Fk. American River and Bear River, near Colfax, California, *C. H. Merriam* (US).

Range: Montane slopes 2500 to 5000 ft. (or as low as 1500 ft. at the north, as high as 7000 ft. at the south), Sierra Nevada of California. Chiefly in a horizontal belt between *A. viscida* or *A. mariposa* (in their respective ranges) and *A. patula*.

Representative Specimens: CALIFORNIA. Butte Co.: e. of Paradise, on Pearson Rd., *Wieslander* (J). Plumas Co.: Paxton, *Faris* (UC). Placer Co.: w. of Blue Canyon, *Brandegee* (UC). Eldorado Co.: Shingle Springs, *Herbert* (J). Calaveras Co.: w. of Calaveras Big Trees, *Adams 522* (UC); Murphy's, *Davy* (UC). Tuolumne Co.: Long Barn, *Adams 768;* Sugar Pine, *Adams 94* (UC); Cold Spring, *Jepson 6456*, type of *A. pastillosa* (J). Mariposa Co.: Stockton Cr., *Congdon* (UC); Mariposa, *Jussel 16* (UC). Tulare Co.: Mineral King to Hammond, *M. S. Baker 4463b* (UC, CA); Cold Spring, N. Fk. Tule Riv., *Jepson 4074* (J).

This species is a relative of *A. patula* which it resembles in the production of a large globose root-crown. However, it is readily distinguished from that species by its open spreading habit, very crooked stems and branches, and by the coloration of its foliage. Where the two species occur together the difference in hue is striking.

The variation in shape and size of leaves in *A. mewukka* is remarkable. Leaves varying in shape from rather broadly ovate to long-lanceolate and narrowly obovate, and in length from 2 to 6 cm. are commonly found on a single plant. The exceedingly large, mahogany colored fruits are distinctive.

14. **Arctostaphylos glauca** Lindl. Bot. Reg. **21,** pl. 1791 (1836).

Xerobotrys glaucus Nutt. Trans. Am. Phil. Soc. ser. 2, **8:** 268 (1843). *Daphnidostaphylis glauca* Klotzsch, Linnaea **24:** 80 (1851). *Arctostaphylos glauca* var. *crimicola* Jepson, Madroño **1:** 78, 91 (1922), type loc. Pinon Wells Mts., n. Colorado Desert, *Jepson 6004* (J). *Arctostaphylos glauca* var. *puberula* J. T. Howell, Leafl. West. Bot. **2:** 70 (1938), type loc. 4 mi. w. of Hernandez, San Benito Co., California, *J. T. Howell*, Sept. 7, 1931 (CA).

Erect shrub or small tree 1.5 to 7 m. high, with a distinct but short trunk, open, usually flattish or rounded crown; bark smooth, deep red; branchlets and young shoots glaucous and glabrous or rarely somewhat puberulent or short stipitate-glandular; leaves pallid-glaucous and glabrous, rounded to broadly ovate to elliptic, obtuse or acute at apex, short-mucronate, mostly truncate or subcordate, or sometimes acute at base, entire or serrulate, 2.5–4.5 cm. long, on short stout petioles; peduncles and rachises glabrous, glaucous; panicle dense, nodding, broad and short; bracts short, broadly ovate, spreading; pedicels glandular, stout, about 5 mm. long; corolla white, 7–8 mm. long; ovary viscid-glandular; fruit globose to ovoid or elliptic, viscid glandular, 12–15 mm. broad, with rather thin leathery pericarp; stone solid, smooth, prominently apiculate. No enlarged root crown is produced.

Type locality: California, *Douglas*.

Range: Dry hill slopes and ridges, 800 to 4500 ft. Foothills and mountains of southern California; northward through the inner South Coast Ranges to Mt. Diablo; southward into the mountains of Baja California.

Representative Specimens: CALIFORNIA. Contra Costa Co.: Donner Canyon, Mt. Diablo, *Jepson 7592* (J); Las Trampas Ridge, *Jepson 6853* (J). Alameda Co.: Arroyo Mocho, near Livermore, *Adams 838* (UC); San Antonio Valley, *Adams 556* (UC). Santa Clara Co.: Loma Prieta, *Elmer 4513* (UC); Mt. Hamilton, *Adams 840* (UC). San Benito Co.: San Benito, *J. T. Howell 11086* (CA); Pinnacles, *J. T. Howell 4603* (CA). Monterey Co.: Cherry Canyon, Jolon, *Dudley* (UC); Arroyo Seco Canyon, *J. T. Howell 5668* (CA). San Luis Obispo Co.: Peachy Canyon, Paso Robles, *Barber A3* (J); Road to Pozo, *Eastwood 15138* (CA). Santa Barbara Co.: Zaca Lake, *Eastwood 558* (CA). Ventura Co.: Frazier Mt. Park, *Hoffman* in 1931 (CA); Pine Cr., Sespe, *Everman* in 1917 (CA). Los Angeles Co.: Castaic Cr. *Jepson 8929* (J); Mt. Lowe Trail, San Gabriel Mts., *Pierson 315* (CA); betw. Haines Canyon and Mt. Lukens, *J. T. Howell 3343* (CA); Arroyo Seco, *Braunton 790* (UC).

Orange Co.: Claymine Canyon, Sta. Ana Mts., *J. T. Howell 2604* (CA). San Diego Co.: Collins Valley, *Jepson 8857* (J); Warner Ranch, *Jepson 8527* (J); Jacumba, *Munz 11952* (UC); Cuyamaca Mts., *Palmer 212* (UC); Fallbrook, *M. E. Jones 3103* (CA). Riverside Co.: Mt. San Jacinto, *Rose* in 1927 (CA); Hamilton Grade, *Hoffman* in 1929 (CA); Juniper Hill, San Jacinto Mts., *Hall 518* (UC). San Bernardino Co.: Icehouse Canyon, *Parish 11990* (UC); San Antonio Canyon, Claremont, Dist. *C. F. Baker 4013* (UC); Quail Springs, *Hilend 71* (CA); Pinon Wells Mts., n. Colorado Desert, *Jepson 6004*, type of var. *eremicola* (J). BAJA CALIFORNIA: Mountains, *Pringle* in 1882 (US); Ensenada to Ojos Negros, *Wiggins & Gillespie 4054* (US, SU); La Huerta, w. base Hanson Laguna Mts., *Goldman 1123* (US); La Grulla, San Pedro Martir Mts., *Goldman 1258* (US); Pinon, n.w. slope San Pedro Martir Mts., *Goldman 1206, 1204* (US).

In certain parts of the range of the species shrubs are encountered having slight modifications of the branchlets. On the lower eastern slopes of Mt. Hamilton, and in the San Antonio Valley, Santa Clara Co., and again in Monterey Co. and the Santa Ynez Mts., there occur frequently shrubs possessing a more or less glandular-hairy indument on the branchlets, peduncles and rachises. Conspicuous in the extreme condition, it imperceptibly grades off into the typical form. This variation appears to be rather concentrated in the regions indicated, although it is occasional elsewhere. As representative of this form we cite:

CALIFORNIA. Arroyo Mocho Creek, Alameda Co., *Adams 565, 561* (UC); San Antonio Valley, *Adams 617* (UC); Copernicus Peak, Mt. Hamilton, *Sharsmith, 527* (UC); Parkfield, Monterey Co., *K. Brandegee* (UC); San Marcos Pass, Santa Barbara Co., *Adams 953* (UC).

A form in which the branchlets, petioles, peduncle and rachises are finely pubescent or puberulent occurs with the typical form in San Antonio Valley, Santa Clara Co., on the hills bordering the San Benito River in San Benito Co., and in the mountains of Los Angeles Co. This form also grades off into the typical glabrous form. As representatives of this variation we cite:

CALIFORNIA. San Antonio Valley, *Adams 563* (UC); Canyon Flat, San Benito Co., *J. T. Howell 8076* (CA); Pinnacles, San Benito Co., *Merriam* (CA); Antelope Valley, Los Angeles Co., *Davy 2527* (UC).

15. **Arctostaphylos viscida** Parry, Bull. Cal. Acad. **2:** 492 (1887).

Arctostaphylos pulchella Howell, Fl. Nw. Am. 416 (1901), type loc. mountains w. of Andersons, *Thos. Howell* in 1886 (UO).

Erect shrub 1 to 4.5 m. high with several crooked stems from the base, with deep red, smooth bark; branchlets and peduncles slender and typically glabrous and glaucous, or sometimes sparsely glandular-hairy or pubescent; leaves pallid-glaucous, glabrous, orbicular, ovate, or elliptic, abruptly acute or obtuse and short-mucronate at apex, rounded or somewhat truncate at base, 2–4 cm. long; petioles slender, 5–8 mm. long; rachises typically glandular, or sometimes glabrous and glaucous; bracts inconspicuous, rarely more than 2 mm. long, ovate-acuminate, reddish, glandular-puberulent; pedicels slender, reddish, glandular-hairy, 6–10 mm. long; sepals ovate, acute, ciliate, pinkish, reflexed in fruit; corolla pink or almost white, 6 mm. long; ovary glabrous, or commonly glandular; fruit small, 6–8 mm. broad, flattened, deep red, glabrous or commonly very glandular, nutlets separable. No enlarged root-crown is produced; the shrubs kill under fire.

Type locality: Ione, Amador Co., California, *Parry*, Mar. 9, 1887.

Range: Rocky or clay hill slopes, 500 to 2500 ft., forming dense thickets. North Coast Ranges from Napa to Del Norte and Siskiyou counties, Calif., and north to southern Oregon; Sierra Nevada foothills of California from Shasta Co. to Calaveras Co.; Tulare Co.

Representative Specimens: CALIFORNIA. North Coast Ranges. Napa Co.: Chiles Mill, *Jepson 9067* (J); Pope Cr., Canyon near Walter's Spring, *J. T. Howell 6139* (CA); St. Helena Cr., near Patton's, *J. T. Howell 1712* (CA). Lake Co.: Hinkley Ranch, near Cobb Valley, *Jussel 381* (UC); Moore Cr., Howell Mt., *Jepson 6826* (J); s. of Lower Lake, *Adams 650* (UC); Middletown, *Adams 574* (UC). Mendocino Co.: *Eastwood 15213* (CA). Tehama Co.: Greasewood Hills, *Jepson* (J). Trinity Co.: *Junkans* in 1915 (CA). Siskiyou Co.: Klamathon, *E. B. Copeland*, Dist. C. F. Baker *3519* (UC). Del Norte Co.: Gasquet, *Eastwood 12234* (CA). Sierra Nevada: Shasta Co.: *Jepson* (J); Delta, *Heller 13084* (UC). Butte Co.: Forest Ranch P. O., *Heller 11403* (UC, CA). Sierra Co.: Downieville, *Eastwood 6773* (CA). Yuba Co.: Woodleaf, *Rose* in 1931 (CA). Placer Co.: n. of Roseville, *Adams 543* (UC); Auburn, *Adams 554* (UC). Eldorado Co.: Louisville, *Eastwood 11132* (CA). Amador Co.: Ione, *Adams 777* (UC). Tuolumne Co.: betw. Jamestown and Sonora, *Adams 619* (UC); Table Mt., Rawhide, *Ferris 1488* (CA). Tulare Co.: N. Fk. Tule Riv., *Jepson 4861* (J); Porterville, *Kelley* in 1922 (CA). OREGON. Oregon-California Boundary, *Eastwood 12046* (CA). Josephine Co.: Mts. w. of Anderson's, *Thos. Howell* in 1886, type of *A. pulchella* (UO); Haye's Hill, *Adams 1077* (UC); w. of Waldo, *Adams 1070* (UC). Jackson Co.: Rogue Elk Hotel, *Henderson 12212*, specimen #1 (UC).

Shrubs of this species growing in the North Coast Ranges appear consistently to produce glandular fruits, while the Sierran plants, with a few exceptions in Tulare Co., produce the typical glabrous fruits. In the central Sierra Nevada *A. viscida* is considerably variable in the nature of the branchlets, varying from the typical glabrous-glaucous condition to one approaching the conspicuous glandular-hairiness of *A. mariposa*. This variant occurs along with the typical form from Butte Co. to Tuolumne Co. In southern Oregon, also with the typical form, is one in which the branchlets are minutely pubescent. In other respects this is indistinguishable from typical *A. viscida* and represents the form described by Howell as *A. pulchella*.

16. **Arctostaphylos mariposa** Dudley, in Eastwood, Sierra Club Publ. **27:** 52 (1902).

Erect shrub 1 to 3 m. high with several stems spreading from the base, but branches tending to be more erect than in the preceding; bark smooth, reddish chocolate or deep red; branchlets greenish, typically long glandular-hairy, the hairs spreading; leaves pallid green or very white-glaucous, varying from glabrous to prominently glandular-hairy, mostly roughish, oval-ovate to rotund or elliptic, shortly acute and mucronate at apex, rounded or truncatish at base, 2–4.5 cm. long; panicle dense, small but many-flowered; bracts inconspicuous, ovate; pedicels glandular-hairy, 5–10 mm. long; corolla pink, 5–6 mm. long; ovary typically densely glandular-hairy; fruit flattened-globose, bright red, viscid-glandular or stipitate-glandular, 5–8 mm. broad, with nutlets irregularly separable. No enlarged root-crown is produced.

Type locality: Millwood and Kings River Canyon, Fresno Co., California, *Eastwood*.

Range: Dry canyon and mountain sides, 2500 to 6000 ft. Foothills of the Sierra Nevada from Amador Co. to Kern Co., Calif.

Representative Specimens: CALIFORNIA. Amador Co.: Volcano, *K. Brandegee* (UC). Calaveras Co.: Murphy's, *T. S. Brandegee* (UC); w. of Calaveras Big Trees, *Adams 520* (UC); Mokelumne Hill, *Adams 836* (UC). Tuolumne Co.: e. of Angels Camp, *Adams 524* (UC); Twain Harte, *Adams 773* (UC); Sonora, *Adams 751* (UC). Mariposa Co.: Yosemite Valley, *Hall 9247* (UC); Wawona, *Jussel 15* (UC); El Portal, *Jepson 5671* (J); Coulterville, rd. to Bower Cave, *J. T. Howell 5574* (CA); Merced Riv. Canyon, Bear Valley, *J. T. Howell 5753* (CA). Madera Co.: North Fork, *Adams 834* (UC); Raymond, *Eastwood 12591* (CA). Fresno Co.: Shaver Lake, *Adams 795* (UC); Big Creek, *Adams 860* (UC); Tehipite Valley, Middle Fk. Kings Riv., *Hall & Chandler*

491 (UC). Tulare Co.: Whittakers Forest, *Merrill* (UC). Kern Co.: Greenhorn Range, *J. T. Howell* (CA).

Individuals of this species which gradually approach the glabrous and glaucous condition of the branchlets and glabrous ovary of *A. viscida* are encountered in the northern and southern parts of the range of *A. mariposa*. These intergrades meet the corresponding variants of *A. viscida* and are in many instances indistinguishable from them.

16a. **Arctostaphylos mariposa** var. **bivisa** Jepson, Madroño **1:** 79, 91 (1922).

Arctostaphylos Jepsoni Eastw. Leafl. West. Bot. **1:** 119 (1934).

Shrub with habit and stature of the species; branchlets dusky glandular-hairy; leaves darker, brighter green, oblong, broadly elliptic or somewhat rounded; ovary glabrous or sparsely white-hairy; fruit glabrous and shining or very sparsely pubescent.

Type locality: Hetch-Hetchy, Tuolumne Co., California, *Jepson 3452* (J).

Range: Tuolumne and Mariposa counties, Calif. and probably farther south.

Representative Specimens: CALIFORNIA. Hetch-Hetchy, *Jepson 3452*, type (J); Yosemite Park near Wawona, *Jepson 5658* (J); above Wawona Tunnel, *Adams 835* (UC); Chowchilla Mt., summit, Mariposa Co., *J. T. Howell 6683*, type of *A. jepsoni* Eastw. (CA); Stella Lake, Wawona, *J. T. Howell 17* (CA). *Adams 793* (UC), collected at Shaver Lake, Fresno Co., is probably this variety.

17. **Arctostaphylos pringlei** Parry, Bull. Cal. Acad. **2:** 494 (1887).

Erect shrub with spreading branches, up to 3 or even 4.5 m. high; bark red-brown, smooth; branchlets stout, conspicuously glandular-hairy; leaves pallid-green, mostly rough with glandular hairs, ovate or oblong, or almost orbicular, 2–5 cm. long, 1–4 cm. wide; inflorescence a large, almost sessile panicle with glandular-hairy rachises and small but conspicuous, lanceolate, pink, membranaceous, deciduous bracts; pedicels long, slender, reddish, prominently glandular-hairy; sepals white, glandular-ciliate; corolla usually rosy, 6–8 mm. long; ovary glandular; fruit dark red, ovoid or spherical, 6–8 mm. broad, with variously separable nutlets. No enlarged root-crown is produced.

Type locality: Lower California, *C. R. Orcutt*, July 1884; Arizona, *C. G. Pringle*, in 1885.

Range: Dry mountain slopes of Arizona and Baja California, 4000 to 7000 ft.

Representative Specimens: ARIZONA: Pine Creek, *M. E. Jones* in 1890 (UC); Copper Basin, *W. Jones* in 1922 (UC); Pinal Mts., *Eastwood 15872* (CA); Skull Valley, *W. Jones* (UC); Globe, *Newlon* (J). BAJA CALIFORNIA: Mt. San Pedro Martir, *T. S. Brandegee* in 1893 (UC, US), in 1894 (UC); La Grulla, San Pedro Martir, *Goldman 1251* (US); Hanson Laguna Mts., *Goldman 1129* (US).

Standley states (Contrib. U. S. Nat. Herb. **23:** 1098 (1924)) that the form in Baja California is var. *drupacea*. From the standpoint of geographical contiguity this might be expected. However, with nonfruiting material it is impossible to tell with which form one is dealing. The few fruiting specimens examined from Baja California have separable nutlets; flowering material is arbitrarily included with the species.

17a. **Arctostaphylos pringlei** var. **drupacea** Parry, Bull. Cal. Acad. **2:** 495 (1887).

Arctostaphylos drupacea McBr., Contrib. Gray Herb. **53:** 16 (1918).

This variety appears to differ from the species only in the consolidation of the nutlets into a single stone.

Type locality: Mountains east of San Diego, California, *C. R. Orcutt 543*, Sept. 1886.

Range: Dry montane slopes, 4500 to 7000 ft. San Bernardino Mts. to Laguna Mts., Calif.; probably southward into Baja California (cf. Standley).

Representative Specimens: CALIFORNIA. San Bernardino Co.: Mill Creek, *Jepson 5588* (J); Mill Cr. Falls, *Parish 5070* (SU); Seven Oaks, *Parish 3709* (UC); Glen Martin, *Munz 12734* (UC). Riverside Co.: Strawberry Valley, *Jepson 1305* (J); Tauquitz, San Jacinto Mts., *Hall 2311* (UC); *2092* (SU). San Diego Co.: Palomar Peak, *Munz 10416* (UC); Julian, *T. S. Brandegee* in 1894 (UC); Monument Peak, Laguna Mts., *Munz* (UC).

There appear to be no differences between this variety and the species that can be correlated with the difference in coalescence of the nutlets. In the species often one small nutlet is separable from the fused remainder, and the markings on the stones of the two forms are approximate.

18. **Arctostaphylos nissenana** Merriam, Proc. Biol. Soc. Wash. **31:** 102 (1918).

Schizococcus nissenanus Eastw. Leafl. West. Bot. **2:** 49 (1937).

Erect shrub .6 to 1.5 m. high with reddish brown or grayish rough and fibrous bark; branchlets slender, long white-villous or glabrate;

leaves pale green, puberulent when young, becoming glabrate and somewhat glaucous with age, elliptic to oblong or somewhat obovatish or rotund, acute or obtuse and mucronate at apex, obtuse or truncatish at base, 1–2.5 cm. long, .5–1.5 cm. wide, on pubescent or villous petioles 2 mm. long; inflorescence small, short raceme with short-villous or glabrate peduncle; bracts foliaceous, oblong-lanceolate to ovate, glabrous or pubescent, ciliate; pedicels glabrous or occasionally densely villous, or sparsely so; sepals slightly ciliate, rosy; corolla rosy, 3–4 mm. long; ovary glabrous or pilose; fruit globose and usually ridged, greenish, glabrous or sparsely hairy, 4–5 mm. broad, with very thin pericarp and separable into 2–5 one-seeded nutlets.

Type locality: 2 or 3 miles north of Louisville, Eldorado Co., California. (Southwest of American Flat and near top of a low ridge, altitude 2300–2400 feet.) August 9, 1907, *C. H. Merriam* (US).

Range: Dry ridges in foothills, 2000 to 2500 ft., Eldorado Co., California.

Originally described without flowers or fruits, this species was not again collected until August 1931 when it was found on a ridge at the mouth of Brush Creek, Eldorado Co., by collectors for the California Forest and Range Experiment Station. It has subsequently been collected at several stations in the vicinity of Placerville, Calif. Of a score or more of specimens examined, the following are cited as representative:

Ridge below left fork, Martinez Creek, *Belshaw 839* (in fruit, pedicels glabrous); *Belshaw 841* (in fruit, pedicels villous) (A). Diamond Springs, *Wieslander* (in flower) (J).

19. **Arctostaphylos canescens** Eastw. Proc. Cal. Acad., ser. 3, **1:** 84 (1897).

Arctostaphylos strigosa Howell, Fl. Nw. Am. p. 417 (1901), type loc. near Waldo, Oregon, *Thos. Howell* in Apr. 1886 (UO). *Arctostaphylos bracteata* Howell, Fl. Nw. Am. p. 417 (1901), type loc. near Waldo, Oregon, *Thos. Howell* in Apr. 1886 (UO).

Erect, straight-stemmed shrub 1 to 2 m. high, or in some situations a low (3 to 6 dm.) dense and knotty shrub; old stems with deep red smooth bark; branchlets densely white-tomentose or downy; young leaves very downy, pale, older ones less so, ovate, oblong-obovate to rotundish, spreading, mostly 2–4 cm. long, 1–2.5 cm. wide, on downy petioles 5–8 mm. long; peduncles and rachises white-tomentose or downy; panicle short, dense; bracts large, foliaceous, usually longer than the pedicels; pedicels pubescent or occasionally somewhat glandu-

lar-pubescent, 5–6 mm. long in flower, or up to 10 mm. in fruit; corolla pink, 8–9 mm. long; ovary densely white-hairy, non-glandular; fruit flattened-giobose, usually pubescent or sometimes slightly glandular or glabrate and with a bloom; nutlets separable. No enlarged root crown is produced.

Type locality: South slopes of Mt. Tamalpais, Marin Co., California, *Eastwood.*

Range: Dry or rocky hill slopes and ridges, 1000 to 4000 feet. North North Coast Ranges from Marin Co. to Del Norte Co., California; southern Oregon in slightly modified form.

Representative Specimens: CALIFORNIA. Marin Co.: Mt. Tamalpais, *Eastwood,* Dist. C. F. Baker *3160, 3994* (UC). Napa Co.: Hood's Peak Range, w. of St. Helena, *Jepson* (J); Mt. St. Helena, *Adams 644* (UC); Cobb Station, *M. S. Baker 2274b* (CA, UC); Snow Mt., *M. S. Baker 3116b* (CA, UC); Cal. Nat. Forest, *M. S. Baker 3114b* (CA, UC); Dashiell's, Mt. Sanhedrin, *Eastwood 12923* (CA). Mendocino Co.: Ukiah, *Eastwood 11378* (CA); Red Mt., *Eastwood* in 1901 (UC); Castle Peak *Jepson* (J); Osborne's, Forest Reserve, *Eastwood 15343* (UC, CA). Glenn Co.: Alder Springs, *Heller 12776* (UC). Del Norte Co.: Black Butte, *Eastwood 2153* (CA); Gasquet, *Eastwood 12130* (CA). OREGON. Josephine Co.: Takilma, *Eastwood & Howell 1680* (CA); Waldo, *Thos. Howell 1451* (UC), in Apr. 1886, type of *A. bracteata* (UO); Waldo, *Thos. Howell* in Apr. 1886, type of *A. strigosa* (UO); Hayes Hill, *Adams 1078* (UC); Anderson's, *Adams 1083* (UC); Eight Dollar Mt., *Henderson 5747* (UC, UO).

On Mt. Tamalpais in exposed situations the species occurs chiefly as a low dense shrub, thickly covering serpentine slopes; in company with other species it tends to be straighter and taller. In Napa and Lake counties and northward into southern Oregon it generally has larger leaves and becomes quite tall and straight. A slight glandularity of fruit and pedicels is occasionally encountered, especially in plants from the northern California counties. *A. strigosa* Howell and *A. bracteata* Howell of southern Josephine Co., Oregon, are the taller, large-leaved form of the northern counties of California. The latter of Howell's species appears to be somewhat greener than the former, but this appears to be due to a difference in the persistence of the pubescence, which is encountered also in California representatives of the species.

19a. **Arctostaphylos canescens** var. **sonomensis** (Eastw.) comb. n.

Arctostaphylos sonomensis Eastw. Leafl. West. Bot. **1:** 78 (1933).

Erect shrub 1 to 1.5 m. or often up to 3 m. high with stem bark and

indument of branchlets as in the species; leaves ovate-lanceolate to elliptic, acute at apex, 2–3 cm. long, 1–2 cm. wide, densely pubescent; flowers white, 7 mm. long, in short dense panicles; bracts foliaceous, tomentulose, longer than the pubescent or somewhat glandular-pubescent pedicels; fruit pubescent or somewhat glandular with separable nutlets. The shrubs produce no enlarged root-crown.

Type locality: Rincon Ridge near Santa Rosa, Sonoma Co., California, *M. S. Baker 3877c* (CA).

Range: Known only from the type locality.

Representative Specimens: Rincon Ridge, near Santa Rosa, Sonoma Co., *Adams 1022, 1025* (UC); *Meyer 301* (UC).

This variety is distinguished from the species chiefly by its longer, ovate-lanceolate and pointed leaves which are somewhat less downy than in the species. The tomentulum of the branchlets agrees well with that of the species; the glandular or viscid pubescence of stem and leaf described by Eastwood is not apparent.

20. **Arctostaphylos pechoensis** Dudley, Abrams N. Am. Fl. **29:** 98 (1914).

Arctostaphylos andersonii var. *pechoensis* Jepson, Madroño **1:** 89, 95 (1923).

Bushy shrub 1 to 1.5 m. or up to 3 m. high, often with a short but definite trunk; bark dark red-brown, smooth; branchlets downy or tomentose, canescent; leaves ovate to somewhat oblong, acute to obtuse or rounded and slightly mucronate at apex, auriculate at base and essentially sessile, or commonly subcordate or truncate and petiolate, the petioles up to 5 mm. long, minutely tomentulose or glabrescent, 1.5–3.5 cm. long, 1.5–2.5 cm. wide; inflorescence a short few-flowered panicle with tomentulose rachises and long, spreading, foliaceous, pubescent bracts; pedicels mostly glabrous but frequently more or less downy; corolla white or pinkish, 6–7 mm. long; ovary glabrous or sparsely hairy toward the top; fruit depressed-globose, glabrous; nutlets variously separable. No enlarged root-crown is produced.

Type locality: Head of Wild Cherry Canyon, Pecho Mts., San Luis Obispo Co., California, April 5, 1902, *W. R. Dudley* (SU).

Range: Hill slopes and ridges, 25 to 2500 ft. West central San Luis Obispo Co., California.

Representative Specimens: CALIFORNIA. Santa Margareta Mts., e. of pass, rd. to San Luis Obispo, *Dudley*, April 1903 (UC, CA, SU); above Klein Mine, *Dudley* in 1905 (SU); Pecho Mts., hd. Wild Cherry

Canyon, *Dudley* in 1902 (SU); Cuesta Pass, *Adams 992, 993, 994* (A); road to Pecho, *Eastwood 15107* (CA); Morro Sand Hills, *Eastwood 14945* (CA); road to Atascadero from Morro, *Eastwood 15009* (CA).

In shape of leaf base and length of petiole a host of intergrades between this species and *A. obispoensis* Eastw. occur on the hills about Cuesta Pass (*Adams 985*). In typical form the leaves of the species are essentially sessile, conspicuously auriculate and imbricated on the stem, but such individuals are comparatively rare. Of more frequent occurrence are forms in which the leaves are definitely petiolate, with bases tending to truncate or subcordate, or even broadly acute, and more spreading. Not infrequently a considerable series of intermediates between the two extremes can be found on a single plant.

On inflorescence characters the chief relationship of *A. pechoensis* would appear to be with *A. canescens*.

20a. **Arctostaphylos pechoensis** var. **viridissima** Eastw. Leafl. West. Bot. **1:** 62 (1933).

Erect shrub 1 to 2.5 m. high with a single trunk-like stem and smooth reddish brown bark; branchlets pubescent or tomentulose and with spreading bristly hairs; leaves dark green or occasionally with a faint glaucous bloom, broadly ovate, glabrous, with rounded or acute and mucronate apex, more or less auriculate, entire or serrulate near base, sessile or on petioles up to 4 mm. long, imbricated, 1.5–2.5 cm. long, 1–2 cm. wide; inflorescence a dense sessile panicle with pubescent rachises and very broad, glabrous, ciliate, leaf-like bracts densely crowded; pedicels glabrous or occasionally sparsely pubescent; sepals ciliate; corolla white, 5 mm. long; ovary glabrous; fruit bright red, glabrous, globose, 6–7 mm. broad with separable nutlets and scanty granular pulp. The shrubs produce no enlarged root-crown.

Type locality: China Harbor, Santa Cruz Island, *J. T. Howell 6368*, Apr. 14, 1931 (CA).

Range: Santa Cruz Is. and west central Santa Barbara and San Luis Obispo counties, California.

Representative Specimens: CALIFORNIA. Santa Cruz Is.: China Harbor, *J. T. Howell 6368*, type (CA), *6356*, *6367* (CA). Santa Barbara Co.: Lompoc, *Adams 948* (UC); La Purissima Ridge, *Mason 8055* (UC); Burton Mesa, *Adams 946;* Shumann Canyon *Adams 944, 945*. San Luis Obispo Co.: Casmalia Hills, rd. to Pt. Sal, *Adams 936* (A), *940* (UC); near Morro Bay, *Sinsheimer* in May 1931 (UC, CA); Pecho Hills, ridge at hd. Davis Canyon, *Adams 997* (A).

All specimens examined from Santa Cruz Island have somewhat pubescent pedicles and fruits, while all from the mainland have these structures glabrous.

ARCTOSTAPHYLOS OBISPOENSIS Eastw. Leafl. West. Bot. **2:** 8 (1937). Type locality Chorro Creek, near San Luis Obispo, California, *Eastwood 16843* and *15125* (CA). This differs from *A. pechoensis* chiefly in having its leaves with petioles 5–7 mm. long, bases somewhat cordate or truncate or frequently acute. Further field study is necessary to determine the significance of the large number of intergrading forms between this and *A. pechoensis*.—San Luis Obispo County. In addition to the type, the following specimens have been examined: Chorro Creek, *Eastwood 16845, 16844* (CA); hills w. of Cuesta Pass, *Adams 987, 986* (A); Burnett Peak, *Adams 1096* (leaves oval to elliptic) (A).

21. **Arctostaphylos andersonii** Gray, Proc. Am. Acad. **11:** 83 (1876).

Arctostaphylos regismontana Eastw. Leafl. West. Bot. **1:** 77 (1933), type loc. Kings Mt., San Mateo Co., California, *Sutliffe* (CA).

Erect shrub 1 to 4 m. or sometimes taller, with a distinct trunk, or occasionally a low bush branching widely at the base; bark smooth, dark red-brown; branchlets densely clothed with a short close pubescence and long white bristles, the latter commonly with an apical gland; leaves pale to dark green, the upper surface usually practically glabrous, the lower varying from glabrous (except mid-rib) to rather prominently glandular-hairy, oblong to oblong-ovate, sessile or nearly so, apex acute or acuminate, entire or serrulate near the auriculate base, more or less imbricated, 3–7 cm. long, 2–3 cm. wide; inflorescence a large sessile panicle with pubescent or somewhat glandular-hairy rachises; bracts foliaceous, glabrous or minutely puberulent and acuminate, or glandular-pubescent, glandular-hispid-ciliate and broadly lanceolate; pedicels glandular, 5–6 mm. long; corolla white or rosy, 6–7 mm. long; ovary densely glandular-hairy; fruit flattened-orbicular, bright red, very glandular-hairy; nutlets separable. The shrubs produce no enlarged root-crown and are killed outright by fire.

Type locality: Ben Lomond near Santa Cruz, California, *Anderson.*

Range: Sandy or stony ridges, 50 to 2000 feet. San Francisco to Santa Cruz and Santa Lucia mountains, Calif.

Representative Specimens: CALIFORNIA. San Francisco Co.: Skyline Boulevard, *Adams 1044* (UC). San Mateo Co.: Kings Mountain, *Sutliffe*, Type (CA); *C. F. Baker 271* (UC, CA, NY); Lake Pilarcitos, *C. T. Blake* in 1893 (UC); Gazos Creek, *Dudley* in 1901 (NY). Santa

Cruz Co.: Miller's Ranch, betw. Gilroy and Watsonville, *Elmer 4810* (UC, NY); Big Basin, rd. to Saratoga, *Adams 808* (UC); Santa Cruz, *Anderson* in 1871 (NY). Monterey Co.: Trail betw. Lucia and San Antonio Riv., *Hall 9998* (UC); Burro trail, Jolon to Gorda, *K. Brandegee* (UC); Sur Ranch, *Davy 7408* (UC).

Gray described this species from the practically glabrous-leaved form which is rather restricted to the region in and near the redwoods in Santa Cruz Co. The examination of an extensive series of specimens from adjacent areas reveals that while the essential features of *A. andersonii* are maintained there is a definite tendency to vary, especially in respect to glandularity, toward the condition found in the Kings Mountain form. Thus *A. regismontana* Eastw. is considered to be the extreme of a series of forms which differ among themselves mainly in the density and distribution of glandular-hairs. It is extremely difficult or impossible to place many specimens because of this blending of characters, and growth-habit helps not at all since both of the extreme forms may be rather low, spreading shrubs or tall and tree-like, sometimes 6 m. high with a distinct trunk-like stem.

KEY TO THE VARIETIES

Pedicels glandular-hairy; ovary glandular.
Corolla 5–6 mm. long; leaves somewhat glaucous.....21a. var. *pallida*
Corolla 3–4 mm. long; leaves bright green, much imbricated on stem
21b. var. *imbricata*
Pedicels pubescent, non-glandular; ovary non-glandular; leaves white-downy
21c. var. *auriculata*

21a. **Arctostaphylos andersonii** var. **pallida** (Eastw.) comb. n.

Arctostaphylos pallida Eastw. Leafl. West. Bot. **1:** 76 (1933).

Spreading shrub 1 to 1.5 m. high; bark dark purple, smooth; branchlets clothed with a dense pubescence and scattered bristly hairs; leaves with a glaucous bloom, glabrous, ovate or oblong with acute and apiculate apex, auriculate at base, margin entire or spinulose-serrulate near basal lobes, sessile, somewhat imbricated, 3–5 cm. long, 1.5–2.5 cm. wide; inflorescence a many-flowered sessile panicle with pubescent and hairy rachises and broadly lanceolate, foliaceous, practically glabrous bracts; pedicels glandular-hairy, 5–7 mm. long; corolla white, 5–6 mm. long; ovary glandular-hairy; fruit bright red, flattened-globular, glandular. No enlarged root-crown is produced.

Type locality: East Oakland Hills, Oakland, California, *W. W. Carruth*, Jan. 1902 (CA).

Range: Stony hillsides and ridges, 500 to 1000 feet. Alameda and Contra Costa counties, California.

Representative Specimens: Oakland Hills, *C. C. Hall 10999* (CA, UC, NY); *Jepson 5715* (J); Moraga Ridge, *Adams 918* (UC).

This variety differs from the species chiefly in its more consistently bushy habit and broader glaucous leaves.

21b. **Arctostaphylos andersonii** var. **imbricata** (Eastw.) comb. n.

Arctostaphylos imbricata Eastw. Proc. Cal. Acad., ser. 4, **20:** 149 (1931).

Low somewhat spreading shrub, but with single short stem at base; bark smooth, red-brown; branchlets glandular-pubescent and long glandular-hairy; leaves bright green, glabrous except on midrib towards base, mostly ovate, acute at apex, cordate or subauriculate at base, sessile, imbricated on stem, 2–3 cm. long, 1–2.5 cm. wide; inflorescence broad, almost sessile, with broad foliaceous viscid and ciliate bracts; pedicels glandular-hairy; corolla white, 3–4 mm. long; ovary glandular-pubescent; fruit globular, 6 mm. broad. No enlarged root-crown is produced.

Type locality: San Bruno Hills, San Mateo Co., California, *Campbell*, June 17, 1915 (CA).

Range: Local in the San Bruno Hills, San Mateo Co., Calif.

Representative Specimens: San Bruno Hills, *Campbell*, Feb. 15, 1915; June 18, 1915.

21c. **Arctostaphylos andersonii** var. **auriculata** Jepson, Madroño **1:** 88, 95 (1923).

Arctostaphylos auriculata Eastw. Bull. Torr. Club **32:** 202 (1905).

Low somewhat spreading shrub or arborescent, 2 to 4.5 m. high with a distinct trunk-like stem; bark smooth, deep red; branchlets white downy and with long more or less bristly hairs; leaves grayish green due to dense downy pubescence, mostly ovate with rounded or acute apex and auriculate base, entire or often serrulate towards base, sessile or nearly so, mostly 2–4 cm. long, 1.5–3 cm. wide, crowded and somewhat imbricated on stem; inflorescence a dense many-flowered panicle with densely white-downy and somewhat bristly-hairy rachises; bracts large, foliaceous, pubescent and sometimes hispid-ciliate, spreading; pedicels about 5 mm. long in flower, or up to 10 mm. in fruit, white downy; corolla white, 6–7 mm. long; ovary densely long white-hairy; fruit dark red, pubescent, orbicular or considerably flattened, 6–8 mm. broad with

separable nutlets and meagre granular pulp. No enlarged root-crown is produced.

Type locality: Trail above Boyd Ranch, Mt. Diablo, California, *Eastwood*.

Range: Rocky slopes. Mt. Diablo and adjacent regions.

Representative Specimens: Mt. Diablo: *Eastwood*, Dist. C. F. Baker *3161* (UC); Sycamore Creek, *Jepson 9739* (J); Rock City, *Adams 852*. Antioch: *K. Brandegee* (UC).

22. **Arctostaphylos pajaroensis** sp. n.

Erect compact shrub with dense crown, 1 to 2 or 3 m. high; bark dark red, exfoliating in shreds but slowly becoming smooth; branchlets clothed with a loose pubescence and with white bristly hairs; leaves ovate-triangulate, acute and mucronate-cuspidate at apex, auriculate-clasping at base, the basal lobes often angular with 1–3 spinules or sometimes rounded and serrulate, sessile, glabrous, with a faint bloom, averaging 2–3 cm. long; inflorescence a dense many-flowered sessile panicle; bracts chiefly oblong, acute, pubescent to glabrate, the lower foliaceous; pedicels pubescent or rarely glabrate, 5–6 mm. long; sepals pink tinged, ciliate; corolla white, about 5–6 mm. long; ovary densely white-hairy; fruit globular, light red, pubescent, with separable nutlets and scanty granular pulp, 6–7 mm. broad. No enlarged root-crown is produced.

Frutex erectus, 1–3 m. altus, densus; corticis laciniosis; ramis junioribus pubescentibus et setosis; foliis ovatis, glabris, viridibus vel subpallidibus, sessilibus, apice acutis, basi auriculatis, angulatis vel serrulatis, 2–3 cm. longis; inflorescentiis dense paniculatis, sessilibus; bracteis foliaceis, viridibus, pubescentibus vel glabratis; pedicellis pubescentibus, saepe glabratis; corolla alba, 5–6 mm. longa; ovariis dense albido-villosis; drupis sparse pubescentibus, non-glandulosis, globosis, 6–7 mm. latis.

Type locality: Sandy hills west of Prunedale, Monterey Co., California, *Adams 883*, University of California Herbarium # 531717.

Range: Northern Monterey Co., Calif., on sandy hills and orange sandstone south of Pajaro River.

Other Collections are: Between Elkhorn and Prunedale, Monterey Co., *Adams 915, 888, 880, 914, 884, 885, 887, 890* (UC); *W. S. Cooper 27-4* (J). Prunedale, on orange sandstone, covering open hills, *Kelly* in 1932 (UC); Pajaro Hills, *H. P. Chandler 429* (UC).

A striking feature of this species is the tardy and uneven exfoliation

of the bark. Its nearest relative appears to be *A. andersonii* from which it can be distinguished by its compact habit, smaller, ovate-triangulate leaves and non-glandular inflorescence. Lateral branches are often decumbent and root in contact with the soil.

23. **Arctostaphylos insularis** Greene, in Parry, Bull. Cal. Acad. **2:** 494 (1887).

Arctostaphylos pungens Greene, *not* H. B. K., Bull. Cal. Acad. **2:** 406 (1887).

Erect shrub 1 to 2.5 m. high, or sometimes arborescent; bark smooth, dark red-brown and grayish-glaucous; branchlets smooth; leaves bright green and shining above, glabrous or minutely puberulent, long-ovate, obtuse to acute at apex, rounded or truncatish at base, 2.5–3.5 cm. or even 5 cm. long, 1.5–2.5 cm. wide; inflorescence a large spreading panicle with slender smooth rachises and small deltoid-acuminate bracts; pedicels long, densely long-glandular-hairy; sepals conspicuously fimbriate; corolla white, 5–6 mm. long; fruit brown, glabrate, flattened-globular, 1–1.5 cm. broad. The shrubs do not produce an enlarged root-crown and are killed by fire (J. T. Howell).

Type locality: Santa Cruz Island, *Greene* in July 1886.

Range: Santa Cruz Is., Calif., sparsely on the coast, more abundantly in the interior.

Representative Specimens: Santa Cruz Island: Fry's Harbor, *Grinnell* in 1903 (UC); Pelican Bay, *Jepson 12102* (J); Head of Cochie Canyon, *J. T. Howell 6302* (CA, NY).

23a. **Arctostaphylos insularis** var. **pubescens** Eastw. Leafl. West. Bot. **1:** 62 (1933).

This variety differs from the species in possessing glandular-hispid branchlets and pubescent rachises and bracts; ovary white-hairy and fruit somewhat pubescent.

Type locality: Santa Cruz Island, *Greene* in July 1886 (CA).

Range: This is the more common form on the coast of Santa Cruz Is., Calif.

Representative Specimens: Santa Cruz Is.: Pelican Bay, *Jepson 12101* (J), *12100* (J); *Abrams & Wiggins 163, 52* (UC, SU).

24. **Arctostaphylos cinerea** Howell, Fl. Nw. Am. p. 416 (1901).

Erect shrub about 1.5 m. high and branching from the base; bark dark chocolate colored, smooth; branchlets with a short cinereous

pubescence; leaves dull ashy green, glabrous or somewhat pubescent, oblong or obovate, obtuse or rounded and cuspidate at apex, cuneate at base, 2.5–3.5 cm. long, 1–2 cm. wide, on pubescent petioles; inflorescence a spreading panicle with pubescent rachises and small lanceolate or ovate-acuminate bracts, the lower somewhat foliaceous; pedicels pubescent; corolla rosy to white, 5–6 mm. long; ovary white-pubescent; fruit flattened-globose, with variously separable nutlets. The shrubs produce an enlarged root-crown from which sprouts arise after fire.

Type locality: Rocky hillsides along eastern base of Coast Mountains near Waldo, Oregon, *Howell* in April, 1886 (UO).

Range: Northern Del Norte Co., California; southern Josephine Co., Oregon.

Representative Specimens: CALIFORNIA. Gasquet, Del Norte Co., *Adams 1051* (A), *1052* (UC). OREGON. Near Waldo, Josephine Co., along eastern base of Coast Mountains, Oregon, *Howell* in April 1886, type (UO).

The writer's collections cited above were directly compared with the type specimen and found to be in close agreement. *A. cinerea* is one of the more clearly marked of Howell's species, but all of them need intensive field study.

25. **Arctostaphylos parvifolia** Howell, Fl. Nw. Am. p. 416 (1901).

Erect bushy shrub with several straight branches from base, about 1 m. high; bark of main stems dark purplish red, smooth; branchlets lightly puberulent or glabrate; leaves bright green, essentially glabrous or lightly puberulent at base, broadly elliptical or oval, conspicuously mucronate, 2.5–3.5 cm. long, 1.5–2 cm. wide, on glabrate petioles 5–6 mm. long; inflorescence a simple compact raceme or little-branched panicle, nodding, with peduncle and rachises lightly puberulent; bracts small, narrowly lanceolate, the lower equalling the sparsely puberulent pedicels; corolla white or pinkish, 5–6 mm. long; ovary sparsely short white-hairy or occasionally densely so; immature fruit sparsely white-hairy. No enlarged root-crown.

Type locality: Near Andersons, Josephine Co., Oregon, *Thos. Howell* in April 1886 (UO).

Range: On dry gravelly hillsides, northern Del Norte Co., California and adjacent Josephine Co., Oregon.

Representative Specimens: CALIFORNIA. Gasquet, Del Norte Co., *Adams 1054* (UC). OREGON. O'Brien's Post Office, w. of Waldo, *Adams 1068* (UC); Andersons, *Thos. Howell 1449*, in April 1892 (UC, NY).

26. **Arctostaphylos columbiana** Piper, Fl. Nw. Coast, p. 279 (1915).

Arbutus tomentosa hispida Hook. Fl. Bor. Am. **2:** 36 (1834), type loc. "Northwest Coast of America," *Menzies*. *Arctostaphylos setosissima* Eastw. Leafl. West. Bot. **1:** 78 (1933), type loc. Mendocino City, Mendocino Co., California, *Eastwood 11457* (CA).

Erect shrub branching from the base or with a short single trunk-like stem, 1 to 3 m. high; bark dark red-brown, smooth; branchlets with a dense tomentum or rather light pubescence and long white rigid hairs, the latter frequently gland-tipped; leaves ovate or oblong-ovate, tomentulose when young, becoming almost glabrous, acute and apiculate at apex, obtuse or rounded-truncate at base, 2–7 cm. long, 1–3 cm. wide on tomentulose and somewhat setose petioles 3–7 mm. long; inflorescence a large dense panicle with tomentulose and somewhat setose rachises; bracts long, lanceolate, foliaceous, finely puberulent or glabrate, usually hispid-ciliate; pedicels pubescent or commonly glandular-hairy, 3–4 mm. long; corolla white, 6 mm. long; ovary densely white-hairy, the hairs often glandular; fruit bright red, usually lightly pubescent and commonly viscid, 6–9 mm. broad, with separable ridged nutlets and copious pulp. No enlarged root-crown is produced; the shrubs kill completely under fire.

Type locality: Near Union City, Mason Co., Washington, *Piper 898;* Vancouver Island to Oregon.

Range: Loamy flats or clay hillsides, 10 to 2500 feet, along the coast. San Francisco Bay northward into Oregon, Washington, and British Columbia.

Representative Specimens: BRITISH COLUMBIA & VANCOUVER IS.: Sooke, *Pineo* in 1901 (UC); Discovery Bay, *Eastwood 9931* (CA); Malahat Mt., *J. T. Howell 754* (CA); w. of Cowichan Lake, *J. T. Howell 7689* (CA); Parkersville, *Hickey* in 1910 (UC). WASHINGTON: w. shore Discovery Bay, *J. T. Howell 7692* (UC, CA, NY); near Blyn, Clallam Co., *J. T. Howell 7705* (CA); Mountaineers Camp, Kitsap Co., *Eastwood 9651* (CA). OREGON: Mosier, Wasco Co., *J. W. Thompson 4059* (NY); Salmon Riv., Clackamas Co., *J. T. Howell 7287* (UC, CA); Carpenterville, Curry Co., *Henderson 10063* (UC, UO). CALIFORNIA: Gasquet, *Adams 1055* (UC); Crescent City, *Adams 1049* (UC); Eureka, *Tracy 2944* (UC); Big Lagoon, Humboldt Co., *Tracy 4403* (UC); Bald Mt., Humboldt Co., *Tracy 6044* (UC); Mendocino City, *Eastwood 11457*, type of *A. setosissima* (CA); Comptche, *Walker 239* (UC); Point Arena, *Adams 820;* Gualala, *Adams 737;* betw. Stewart's Pt. and Ft. Ross, *M. S. Baker 3728* (UC, CA); Ft. Ross, *Adams 731* (UC); Inverness, *M. S. Baker 3621c* (UC, CA).

Eastwood has segregated the plants of the Mendocino Coast as *A. setosissima* on the basis of their extreme hispidity, leaf size, and more pronounced glandularity of the inflorescence. There appears to be no constant relationship among these various characters. Many plants of the extreme northern part of the range possess very hispid stems in company with small oblong leaves and non-glandular inflorescence and fruit. On the other hand, glandularity is commonly lacking in the very hispid large-leaved plants of the Mendocino Coast and southward.

Thus the glandular and very hispid plants of the southern part of the range appear to be an accented southern phase of the northern *A. columbiana*, with geographic limits scarcely definable and with an overlapping of characters which renders specific delimitation practically impossible.

26a. **Arctostaphylos columbiana** var. **tracyi** (Eastw.) comb. n.

Arctostaphylos tracyi Eastw. Leafl. West. Bot. **1:** 79 (1933).

Erect shrub 1.5 to 3 m. high; branchlets tomentulose, without hispid hairs; leaves mostly ovate or ovate-elliptic, glabrous, with acute apex and obtuse base, 3–5 cm. long, 2–3 cm. wide, on puberulent petioles about 5 mm. long; bracts narrowly lanceolate, puberulent or glabrous; corolla white; ovary densely white-hairy, non-glandular. No enlarged root-crown is produced, and the shrubs are completely killed by fire.

Type locality: Big Lagoon, Humboldt Co., California, *J. P. Tracy 6141* (CA).

Range: Coastal region of Humboldt Co., California.

Representative Species: CALIFORNIA. Big Lagoon, Humboldt Co., *J. P. Tracy 6141*, type (CA); Patrick's Point, *Adams 1046, 1048* (UC); Chamise Mt., near Shelter Cove, *Tracy 6382* (UC, J); Table Bluff, Humboldt Bay, *Tracy 6168* (UC).

Marked similarity of habit, foliage, and inflorescence clearly ally this form with *A. columbiana*, while the fairly constant absence of hispid hairs on the stem and its more or less local distribution within the range of the species serve to establish its varietal position under that species. A few plants are encountered in the region which, while agreeing with this variety in most respects, possess a very few scattered hispid hairs on the branchlets.

27. **Arctostaphylos virgata** Eastw. in Sarg. Trees & Shrubs **1:** 203, pl. 96 (1905).

Arctostaphylos glandulosa var. *virgata* (Eastw.) Jepson, Madroño **1:** 87, 94 (1922).

Erect shrub with single trunk-like stem and smooth red-brown bark, 1.5 to 4.5 m. or even 6 m. high; branchlets virgate, slender, densely clothed with short dark-glandular hairs which also invest the short petioles and extend up the midrib and margins of the leaves; leaves noticeably thin, bright green, glabrate, narrowly ovate to lanceolate, acute and mucronate at apex, obtuse at base, 3–5 cm. long, 1–3.5 cm. wide; inflorescence a dense panicle with conspicuous lanceolate, sharp-pointed, glandular-ciliate bracts; pedicels glandular; sepals ovate, glandular-ciliate; corolla white or pink tinged, 5–6 mm. long; ovary glandular-hairy; fruit flattened-globular, brownish red, viscid; nutlets separable. The shrubs do not produce an enlarged root-crown.

Type locality: Bootjack Trail, Mt. Tamalpais, Marin Co., California, *Eastwood.*

Range: Mountain slopes, 700 to 1500 feet. Southern Marin Co., Calif., near the redwoods.

Representative Specimens: CALIFORNIA. Marin Co.: Mt. Tamalpais, *Eastwood,* Dist. C. F. Baker *3158, 3999;* Railroad Grade, Mt. Tamalpais, *Adams 873* (UC); entrance to Muir Woods, *Adams 872* (UC); Bolinas Ridge, *Jepson 10309* (J).

The erect virgate habit of this plant and its lack of an enlarged root-crown ally it with *A. columbiana* rather than with *A. glandulosa.*

28. **Arctostaphylos glandulosa** Eastw. Proc. Cal. Acad., ser. 3, **1:** 82 (1897).

Arctostaphylos intricata Howell, Fl. Nw. Am. p. 416 (1901), type loc. Gasquet, Del Norte Co., California, *Thos. Howell* in April 1886 (UO).

Erect spreading shrubs 1 to 1.5 m. or in some situations up to 3 m. high, usually with several crooked, smooth stems arising from an enlarged woody base; branchlets coarse, conspicuously glandular-hairy; leaves dark green, more or less glandular-hairy or becoming glabrate in age, elliptic-ovate, with apex acute or obtuse and mucronate, somewhat acute or obtuse at base, 2.5–4 cm. long, 1–2.5 cm. wide, on prominently glandular-hairy petioles 6 mm. or more long; inflorescence a short spreading panicle with glandular-hairy peduncle and rachises; bracts lanceolate, foliaceous, glandular-hairy; pedicels glandular; corolla white, 6–8 mm. long; ovary glandular-hairy; fruit brown-red, very viscid or often scarcely so; nutlets variously separable. An enlarged root-crown is produced from which sprouts freely arise after fire.

Type locality: Mt. Tamalpais, Marin Co., California, *Eastwood.*

Range: Gravelly or clay hill slopes 1000 to 5500 feet. Coast Ranges

from Coos Co., Oregon to Orange Co., Calif., keeping mostly to the coastward hills; Santa Catalina Island.

Representative Specimens: OREGON: Bandon, Coos Co., *Abrams & Benson 10618* (SU). CALIFORNIA: Del Norte Co.: Gasquet, *Adams 1053* (UC); *Thos. Howell* in Apr. 1886, type of *A. intricata* (UO); French Hill, *Eastwood 15051* (CA). Humboldt Co.: Grasshopper Peak, Canoe Cr., *Jepson 16479* (J). Mendocino Co.: Eureka, *Abrams 6985* (NY); Red Mt., *Jepson 16523* (J); Gould Ranch, sw. of Ukiah, *Jepson 7640* (J); Chamise Ridge, Bell's Springs, *Davy* (UC). Lake Co.: Elk Mt., *Tracy 2550* (UC); Bear Creek Camp, *M. S. Baker 3008b* (UC, CA); Mt. Hanna to Clear Lake, *Jepson 14703* (J). Napa Co.: Mt. St. Helena, *Eastwood* (CA). Sonoma Co.: Seaview, on Cazadero Rd., *Adams 728*. Marin Co.: Bootjack Trail, Mt. Tamalpais, *Adams 604* (UC); *Eastwood* in 1903, Dist. C. F. Baker *3995*. Monterey Co.: Devil's Peak, *Ashley 6a* (UC); Danish Creek, *Ashley 5* (UC). Santa Barbara Co.: Gaviota Pass, *Lemmon* in May 1878 (UC); Mountains behind Santa Barbara, *K. Brandegee 19* (UC). Los Angeles Co.: Mt. Wilson, *Abrams 2628* (NY). Orange Co.: Santiago Peak, *Munz 7741* (UC). Santa Catalina Is.: Avalon, *Trask* in 1900 (NY).

In many areas within the range of the species, and in some instances in small contiguous areas, various forms occur which in habit, reaction to fire, and more important morphological characters clearly belong to this species. The majority of these forms appear to represent sporadic variations from the type, closely intergrading with it and each other and occupying a place of little moment in the general complex. Other forms of wider geographic extent occur which might be called "phases". As illustrative of this might be mentioned most of the general northward extension of *A. glandulosa*. The species seems to become progressively lighter of foliage and less glandular as one traces it northward from San Francisco Bay, although at many points exceedingly glandular and dark-leaved individuals reappear. A notable example of this is the recurrence in northern Del Norte Co. and southern Oregon of a very glandular and dark-leaved form indistinguishable from the Mt. Tamalpais shrubs. The Oregon plant has been described as *A. intricata* Howell.

There are, however, mostly to the south of San Francisco Bay, several rather conspicuous, fairly constant, definable forms which occupy areas of appreciable extent within the range of the species.

The relative stabilization and areal importance of these South Coast forms in contrast to the situation within the species in the North Coast Ranges may have its explanation in the suggestion of Mason previously referred to.

Many of these local southern facies of *A. glandulosa*, herein regarded as varieties, have been recently described as new species. Field study of the majority of these forms has left little doubt of their very close relationship to *A. glandulosa*, a relationship that is rendered obscure by their treatment as units coördinate with the species.

KEY TO THE VARIETIES

Leaves light or yellowish green or pallid.
Branchlets non-glandular.
Inflorescence and ovary glandular; leaves yellowish green; Monterey Co. 28a. var. *howellii*
Inflorescence and ovary non-glandular.
Branchlets canescently tomentulose; leaves with a light bloom 28b. var. *cushingiana*
Branchlets long white-hairy.
Inflorescence large, spreading, many-flowered; Mt. Hamilton 28c. var. *campbellae*
Inflorescence small, compact, few-flowered.....28d. var. *mollis*
Branchlets glandular-hairy.
Leaves very pallid, scabrous; Sta. Barbara Co.....28e. var. *zacaensis*
Leaves light green, smooth.....28f. var. *australis*
Leaves dark green; coastal, San Diego Co.....28g. var. *crassifolia*

28a. **Arctostaphylos glandulosa** var. **howellii** (Eastw.) comb. n.

Arctostaphylos howellii Eastw. Leafl. West. Bot. **1:** 123 (1934).

Shrub with habit of the species; bark smooth, brownish red; branchlets white-pubescent, non-glandular; leaves pale yellowish green, elliptic to almost orbicular, apex acute to rounded, base acute or obtuse, pubescent on both surfaces, 3–4.5 cm. long, 1–2 cm. wide; all parts of inflorescence glandular; fruit glandular. An enlarged root-crown is produced.

Type locality: Arroyo Seco River, Santa Lucia Mts., Monterey Co., California, *J. T. Howell 5687* (CA).

Range: Gravelly ridges and canyons, central Monterey Co., California.

Representative Specimens: CALIFORNIA. Monterey Co.: Arroyo Seco, Santa Lucia Mts., *J. T. Howell 5687*, type of *A. howellii* (CA); *J. T. Howell 5686, 5684* (CA); Los Burros Cr., *St. John* (UC); Memorial Park, *Adams 871* (UC).

28b. **Arctostaphylos glandulosa** var. **cushingiana** (Eastw.) comb. n.

Arctostaphylos cushingiana Eastw. Leafl. West. Bot. **1:** 75 (1933). *Arctostaphylos canescens* Eastw., Jepson, Man. Fl. Pl. p. 749 (1925), in part.

Shrub with habit of the species; bark dark purplish brown; branchlets more slender than in species and clothed with a white non-glandular pubescence; leaves bright green, or somewhat pale due to a light bloom, ovate to elliptic, with acute apex and acute or obtuse base, 2–4 cm. long, 1.5–2.5 cm. wide, with pubescent petioles about 5 mm. long; peduncle and rachises pubescent, non-glandular; bracts foliaceous, the upper ones somewhat less so, pubescent; pedicels glandular hairy or commonly non-glandular; corolla white, 6–8 mm. long; ovary densely white-hairy, non-glandular; fruit sparsely pubescent, non-viscid. A much enlarged root-crown is produced.

Type locality: South side of Mt. Tamalpais, Marin Co., California, *Eastwood 11075a* (CA).

Range: Abundant on south slopes of Mt. Tamalpais; northward in Marin, Napa, and Sonoma counties, Calif. Specimens from Twin Sisters Peak and Miller Canyon, Vaca Mts., appear to be this variety.

Representative Specimens: CALIFORNIA. Marin Co., Mt. Tamalpais: south side, *Eastwood 11075a*, type (CA); *Eastwood* in 1903, Dist. *C. F. Baker 3997;* Bootjack Trail, *Adams 595* (UC); near Memorial Tree, *Adams 599* (UC); trail to Upper Rattlesnake, *Adams 610* (UC). Sonoma Co.: e. of Warfield, *J. Clausen 726* (UC); Rincon Ridge, near Santa Rosa, *Adams 1020* (UC). Napa Co.: near Mt. St. Helena, *J. T. Howell 4562* (CA). Solano Co.: Miller Canyon, Vaca Mts., *Jepson 14702* (J); summit of Twin Sisters Peak, *Jepson 2391* (J).

28c. **Arctostaphylos glandulosa** var. **campbellae** (Eastw.) comb. n.

Arctostaphylos campbellae Eastw. Leafl. West. Bot. **1**: 74 (1933).

Shrub with habit of the species; branchlets with rather dense pubescence or tomentulum and coarse white spreading hairs; leaves yellowish green, pubescent below, pubescent or glabrate above, with acute apex and obtuse base; panicle large, spreading, many-flowered with long foliaceous lanceolate bracts, the upper ones becoming short-deltoid; pedicels pubescent; corolla white, 5–6 mm. long; ovary white-hairy, non-glandular; fruit sparsely hairy. An enlarged root-crown is produced from which numerous sprouts arise after fire.

Type locality: Mt. Hamilton, California, *Campbell*, May 5, 1922 (CA).

Range: Local on Mt. Hamilton.

Representative Specimens: Mt. Hamilton: Lower slopes, *Adams 619* (UC); ridge n.e. Mt. Hamilton, *Chandler 6046* (UC); along San Antonio Rd., *Adams 559* (UC).

As shown by its growth habit, inflorescence, and production of an enlarged root-crown, this shrub is related to *A. glandulosa* rather than to *A. canescens* as Eastwood suggests.

28d. **Arctostaphylos glandulosa** var. **mollis** var. n.

Shrub 1 to 1.5 m. high with crooked much-branched stems arising from an enlarged root-crown; bark dark red; young branchlets dark, puberulent, with scattered long soft non-glandular hairs; leaves elliptic-ovate mostly with obtuse or acute base and acute or obtuse and obscurely apiculate apex, light green but not pallid, mostly dull to semi-shining, thick, the younger sparsely puberulent on both surfaces, the older ones practically glabrous, 2–4 cm. long, 1–2 cm. wide; inflorescence small, compact, few-flowered with short, puberulent and more or less sericeous-hairy peduncle; bracts various, mostly foliaceous, lanceolate, ciliate; pedicels pubescent or slightly glandular-pubescent, 5 mm. long; sepals ciliate, reflexed in fruit; corolla white, 5–6 mm. long; ovary densely long-white-hairy, non-glandular.

Frutex erectus, divaricato-ramosus, 1–1.5 m. altus; ramis junioribus pubescentibus et albido-hirsutis, non-glandulosis; foliis pallido-viridibus, glabrescentis, ellipticis vel ovatis, apice acutis, basi acutis vel obtusis, 2–4 cm. longis, 1–2 cm. latis; paniculis parvis, compactis, parce floridibus; bracteis foliaceis, hirsuto-ciliatis; pedicellis pubescentibus vel glandulosis; corolla alba, 5–6 mm. longa; ovariis dense albido-villosis, non-glandulosis.

Type Locality: La Cumbre Peak, Santa Ynez Mts., Santa Barbara Co., California, *Adams 954* (University of California Herb. # 531718).

Range: Rocky and gravelly slopes and summits, 2500 to 4400 feet, Santa Barbara and Los Angeles counties, Calif. It is to be expected in Ventura Co.

Other collections are: CALIFORNIA. Santa Barbara Co.: Ridge to La Cumbre Peak, *Adams 955* (UC); San Marcos Pass, *Adams 949, 952* (UC); summit road to Montecito, *Adams 958* (UC); Santa Barbara, *Elmer 3799* (NY); Santa Barbara, *K. Brandegee* (UC). Los Angeles Co.: San Francisquito Canyon, *Parish 1957* (UC); Arroyo Seco, San Gabriel Mts., *J. T. Howell 3347* (CA); Manzana, *Davy 2464* (UC).

28e. **Arctostaphylos glandulosa** var. **zacaensis** (Eastw.) comb. n.

Arctostaphylos zacaensis Eastw. Leafl. West. Bot. **1:** 79 (1933).

Shrub with habit and glandularity of the species; leaves pale grayish green, ovate, entire or serrulate, obtuse or acute and apiculate at apex,

obtuse at base, pubescent and somewhat scabrous, glandular-hairy near petiole, 4–6 cm. long, 2–4 cm. wide. An enlarged root-crown is produced.

Type locality: Hills above Zaca Lake, Santa Barbara Co., California, *Eastwood 681* (CA).

Range: Rocky slopes in vicinity of Zaca Lake, Santa Barbara Co., Calif.

Representative Specimens: Zaca Lake, *Eastwood 681*, type of *A. zacaensis* (CA); *Eastwood 619* (CA); Divide betw. Zaca Lake and Manzana Creek, *Merriam* in 1911 (UC).

28f. **Arctostaphylos glandulosa** var. **australis** var. n.

Shrub 1 to 2.5 m. high with habit and glandularity of the species; leaves light green but not pallid, smooth with dull lustre, mostly ovate-elliptic, acute or obtuse at base, acute and apiculate at apex, 3 cm. long, 1–2 cm. wide.

Frutex erectus, 1–2.5 m. altus; ramis junioribus glanduloso-hirsutis; foliis pallido-viridibus, ovato-ellipticis, apice acutis et apiculatis, basi acutis vel obtusis, circa 3 cm. longis, 1–2 cm. latis; bracteis foliaceis, glanduloso-villosis; pedicellis glandulosis; ovariis glanduloso-villosis.

Type locality: West slopes of Otay Mountain, San Diego Co., California, *Adams 974a* (University of California Herb. # 531719).

Range: Clay and gravel slopes and summits, coastward mountains of San Diego Co.; probably also on adjacent mountains of Orange and Los Angeles counties, Calif. and Baja California.

Other collections are: CALIFORNIA. San Diego Co.: summit of Otay Mt., *Adams 974 series* (UC); west ridge, Otay Mt., *Adams 977* (UC); near Alpine, *Fleming* in 1922, in 1923 (CA); Descanso, *Eastwood 9090* (CA).

28g. **Arctostaphylos glandulosa** var. **crassifolia** Jepson, Madroño **1:** 86, 94 (1922).

Arctostaphylos tomentosa var. *crassifolia* Jepson, Man. Fl. Pl. Calif. p. 749 (1925).

Shrub up to 1.2 m. high, with habit of the species; bark smooth; branchlets tomentulose and occasionally with scattered soft white hairs, non-glandular; leaves dark green, dull or somewhat glossy, thickish, broadly elliptic or oval, apex acute, obtuse or rounded and obscurely apiculate, mostly obtuse at base, glabrate above, tomentulose or glabrate

below, 2–4.5 cm. long, 1.5–3 cm. wide; pedicels pubescent; fruit sparsely pubescent or glabrous, non-glandular.

Type locality: Del Mar, San Diego Co., California, *Jepson 1606a* (J).

Range: Sand mesas near the coast from Oceanside to San Diego, Calif.

Representative Specimens: CALIFORNIA. San Diego Co.: Oceanside, *K. Brandegee* (UC); Solana Beach, *Adams 960* (UC); Del Mar, *Jepson 1606a*, type (J); Del Mar, *Adams 1012, 968* (branchlets white-hairy) (UC); Torrey Pines Park, *Adams 962* (UC); San Diego, *G. W. Dunn* in 1891 (UC).

Specimens from Baja California, *Brandegee* in 1889 (US), appear to be this variety.

ARCTOSTAPHYLOS OBLONGIFOLIA Howell, Fl. Nw. Amer. p. 416 (1901). Type loc. "Rocky hillsides, eastern base of the Coast Mountains near Waldo, Oregon," *Howell* in April, 1886 (UO). Erect, 1 to 1.5 m., with several crooked stems from enlarged root-crown; branchlets with a short grayish pubescence; leaves dull grayish green, lightly puberulent, oblong to oblong-ovate, obtuse or acute at apex, obtuse at base, 2–3 cm. long, 1–2.5 cm. wide; inflorescence a spreading panicle with lanceolate or ovate-acuminate pubescent bracts; pedicels pubescent; corolla white, 5 mm. long; ovary moderately white-hairy; fruit sparsely pubescent.—Josephine Co., Oregon and northern Del Norte Co., California. Near Waldo, Ore., *Howell 1452* (UC); w. of Waldo, *Adams 1061* (UC); 5 mi. s. of Siskiyou Mt. Camp, California, *Adams 1060* (UC) (matched with type). This has been related by Eastwood to *A. viscida* on the basis of specimens collected in vicinity of Waldo, *Eastwood & Howell 1686, 1418*, etc. (CA). The writer's collections were directly and closely compared with the type and found to be in perfect agreement. The foliaceous-bracted inflorescence of *A. oblongifolia* is quite unlike that of *A. viscida*, and the writer's collections are definitely known to have come from plants with conspicuously enlarged root-crowns, a condition unknown in *A. viscida* and its close relatives. It appears to be a part of the non-glandular, pale-leaved northern phase of *A. glandulosa*. It is in need of further field study.

29. **Arctostaphylos crustacea** Eastw. Leafl. West. Bot. 1: 74 (1933).

Erect shrub 6 dm. to 2 m. high with several spreading stems arising from an enlarged root-crown; bark smooth, dark purple; branchlets with long white hairs often arising from an understory of dense or loose pubescence, or the former sometimes lacking, non-glandular or occasionally slightly so; leaves bright green, brittle, oblong-ovate to rounded

or broadly lanceolate, acute or rounded and apiculate at apex, mostly truncatish or subcordate at base, upper surface glabrous and usually rather glossy, lower surface glabrous or lightly pubescent, 2–4 cm. long, 1.5–2.5 cm. wide, on pubescent and commonly hairy petioles 5–8 mm. long; bracts of inflorescence foliaceous, the lowermost lanceolate, the upper commonly becoming deltoid-acuminate, pubescent or sometimes glandular; pedicels pubescent or glabrate or sometimes glandular; corolla white or pinkish, 5–6 mm. long; ovary densely or sparsely white-hairy or glabrous, non-glandular; fruit dark red, sparsely pubescent or glabrate, 6–8 mm. broad; nutlets variously separable.

Type locality: Kings Mountain, San Mateo Co., California, *Seale*, April 2, 1922 (CA).

Range: Dry gravelly or rocky slopes and ridges, 50 to 1800 feet; southward from Contra Costa Co. to Santa Barbara Co., California; Santa Cruz and Santa Rosa islands.

Representative Specimens: CALIFORNIA. Contra Costa Co.: Redwood Ridge, *Constance 487* (UC); Moraga Ridge, *Adams 921* (UC); Mt. Diablo, *Adams 680* (UC). Alameda Co.: Oakland Hills, *Jepson 7440* (J). San Francisco Co.: Skyline Boulevard, *Adams 1043* (UC). San Mateo Co.: Kings Mt., *Seale*, type (CA); Dist. *C. F. Baker 817*. Santa Clara Co.: Watsonville, Dist. *C. F. Baker 1966;* Los Gatos, *Heller 7250* (UC); Greninger Cr., *Jepson 9688* (J). Santa Cruz Co.: Saratoga, *Adams 924* (UC); Bonnie Doon Ridge, *Adams 926;* East Gate, Big Basin Park, *Adams 814* (UC). Monterey Co.: Prunedale, *Adams 892* (UC); Elkhorn, *Adams 916* (UC). San Luis Obispo Co.: Davis Canyon, Pecho Hills, *Adams 1005* (UC); Cuesta Pass, *Adams 991* (UC). Santa Barbara Co.: La Purissima Ridge, *Mason 8052* (UC); hd. Purissima Canyon, *Adams 1016* (UC). Santa Cruz Is.: Ravenswood, *J. T. Howell 6229* (CA). Santa Rosa Is.: Canada de la Cobo, *Hoffmann* in 1932 (CA).

This species has long been identified with *A. glandulosa* which it resembles in growth habit. However, it shows a striking and constant difference from that species in the shape of the leaf base and in the distribution of stomata on the leaf surfaces. *A. glandulosa* and its varieties have stomata more or less equally distributed on both surfaces of the leaves, while in *A. crustacea* they are restricted to the lower surface. Correlated with this difference is one involving shape of leaf base. The leaf base of *A. glandulosa* and varieties is consistently acutish or obtuse, whereas the leaves of *A. crustacea* and its varieties are almost invariably truncate to subcordate.

In texture and coloration of leaf the plants show considerable varia-

bility. Those in the northern part of the range have relatively thin leaves, while the plants of the southern part, as especially in the region around Lompoc, Santa Barbara Co., have very thick, coriaceous leaves.

As the species is traced southward from its northern limit the pubescence of pedicel and ovary appears gradually to decrease, culminating in a practically glabrous condition of those parts in most shrubs of the species in Santa Barbara Co. However, the specimens cited for Santa Cruz and Santa Rosa Islands, while matching very closely the plants of La Purissima Ridge in all other respects, have pedicels and ovary pubescent.

29a. **Arctostaphylos crustacea** var. **rosei** (Eastw.) comb. n.

Arctostaphylos rosei Eastw. Leafl. West. Bot. **1**: 77 (1933).

Erect shrub with habit of the species, about 1 m. high; branchlets pubescent but without spreading hairs; leaves somewhat longer and narrower, 4–6 cm. long, 1–2.5 cm. wide.

Type locality: Lake Merced, San Francisco, California, *L. S. Rose 33037* (CA).

Range: Hills bordering Lake Merced, San Francisco Co., Calif.

Representative Specimens: Lake Merced, *Rose 34029* (CA); *Eastwood* in 1907 (CA).

29b. **Arctostaphylos crustacea** var. **tomentosiformis** var. n.

Erect shrub with habit and stature of the species; branchlets densely white-tomentose and with spreading white bristly hairs; leaves 2.5–5 cm. long, 1.5–2.5 cm. wide, the lower surface densely white-tomentose.

A specie differt: foliis longioribus, subtus dense tomentosis; ramis junioribus dense albido-tomentosis.

Type locality: Bonnie Doon Ridge, Santa Cruz Co., California, *Adams 928* (University of California Herb. # 531720 and # 531721).

Range: Dry hills and ridges east of Santa Cruz; hills around Monterey Bay; Año Nuevo Point.

Other collections are: CALIFORNIA. San Mateo Co.: Año Nuevo Point, *J. T. Howell 10987* (CA). Santa Cruz Co.: Saratoga, *Eastwood* in 1929 (CA); Big Trees Grove, *Sonne* in 1887 (UC); Sta. Cruz Mts., e. of Sta. Cruz, *Jepson 9779* (J); Mt. Hermon, *Adams 856, 863* (UC); Bonnie Doon Ridge, *Adams 926, 925, 927* (UC). Monterey Co.: Monterey, *Jepson 2991* (J); Pine Barrens, Cypress Point, *Wolf*, Rancho Sta. Ana Herb. *1816* (UC, SU).

ARCTOSTAPHYLOS SUBCORDATA Eastw. Leafl. West. Bot. **1:** 61 (1933). Type locality w. end of Santa Cruz Island, California, *J. T. Howell 6335* (CA). Openly branching shrub 1 to 2 m. high with smooth red-brown bark; branchlets pubescent and with spreading glandular hairs; leaves dark green, ovate-elliptical or lanceolate with subcordate, truncate, obtuse or acute base, on hispid petioles; panicle sessile, dense; bracts foliaceous, viscid, glandular-ciliate; pedicels glandular; ovary white-hairy; fruit globular, sparsely pubescent. Stems arise from an enlarged root-crown (J. T. Howell).—Santa Cruz Is.: Pelican Bay, *Jepson 12083* (J); *J. T. Howell 6401* (CA); Ravenswood, *J. T. Howell 6230* (CA). Type seen. Specimens originally cited for this species appear to represent a mixture of forms. The type and the above cited specimens which agree with it are a glandular variant of *A. crustacea*. Further collection and field observation are needed.

ARCTOSTAPHYLOS CONFERTIFLORA Eastw. Leafl. West. Bot. **1:** 122 (1934). Type locality Santa Rosa Island, California, s.e. of Black Mt., *Hoffmann 141* (CA). Erect shrub, or prostrate on exposed rocky ledges; branchlets dark glandular-hispid; leaves bright green, ovate or oval with subcordate base and rounded apex, glabrous and shining above, glandular-hairy or glabrous below, on glandular-hairy petioles; bracts broad, foliaceous, obtuse at apex, glandular; fruit and flowers not seen.—Santa Rosa Is.: Above Water Canyon, *Hoffmann 153* (CA). In bud the broad foliaceous bracts impart a dense crowded aspect to the inflorescence. It appears to be a glandular island variant of *A. crustacea*.

30. **Arctostaphylos tomentosa** (Pursh) Lindl. Bot. Reg. **21:** t. 1791 (1836).

Arbutus tomentosa Pursh, Fl. Am. Sept. **1:** 282 (1814), type loc. "Northwest Coast of America," *Menzies*. *Arbutus tomentosa nuda* Hook. Fl. Bor. Am. **2:** 36 (1834). *Arctostaphylos tomentosa nuda* Lindl. Bot. Reg. **21,** t. 1791 (1836). *Arctostaphylos cordifolia* Lindl. Bot. Reg. **21,** t. 1791 (1836), type loc. "Northwest America," *Menzies*. *Xerobotrys cordifolius* Nutt. Trans. Am. Phil. Soc., n. s. **8:** 268 (1843). *Xerobotrys tomentosus* Nutt. Trans. Am. Phil. Soc., n. s. **8:** 267 (1843). *Daphnidostaphylis tomentosa* Klotzsch, Linnaea **24:** 79 (1851). *Daphnidostaphylis cordifolia* Klotzsch, Linnaea **24:** 81 (1851). *Arctostaphylos vestita* Eastw. in Sarg. Trees & Shrubs **1:** 205 (1905), type loc. Monterey, *Eastwood*. *Arctostaphylos glandulosa* var. *vestita* Jepson, Madroño **1:** 86, 94 (1922).

Erect loosely branching shrub 1 to 2 or 2.5 m. high, usually with a

single somewhat crooked trunk arising from a swollen root-crown; bark exfoliating in long shreds, these persistent; branchlets clothed with a dense whitish tomentum; leaves oblong to broadly elliptic or broadly ovate, truncate or subcordate at base, acute and apiculate at apex, 2.5–4.5 cm. long, 1.5–2.5 cm. wide, upper surface glabrous and shining, lower surface densely white-tomentose, on short stout tomentulose petioles; inflorescence a short sessile spreading panicle with densely tomentose rachises; bracts large, foliaceous, spreading, tomentulose; pedicels pubescent, non-glandular; corolla white, 5–6 mm. long; ovary densely white-hairy, non-glandular; fruit flattened-globular, 8–10 mm. broad, brownish red, pubescent; nutlets variously separable, wrinkled on back; granular pulp copious. Sprouts arise from the enlarged root-crown after fire.

Type locality: "Northwest Coast of America," *Menzies*.

Range: Open pine woods or dry hills, 10 to 500 feet. Vicinity of Monterey Bay; San Simeon, San Luis Obispo Co.

Representative Specimens: CALIFORNIA. Monterey, *Eastwood*, Dist. *C. F. Baker 4000, 4880, 2476*. Pacific Grove, *Elmer 3525* (UC, CA); *Heller 6475* (UC, SU); *Adams 911* (UC). Seaside, *Adams 697* (UC); *Elmer 4932* (CA, UC, SU). Del Monte, *Heller 6495* (UC, SU). San Simeon, *K. Brandegee 17* (UC).

The following collections were compared directly with the type specimen of the species in the Natural History Museum, South Kensington, London, in the summer of 1935 by Dr. W. L. Jepson and found to be in striking agreement with it: Pacific Grove, *Adams 901, 902, 905, 908, 910, 912* (UC).

The interpretation of the type sheet of *A. tomentosa* (Pursh) Lindl. at present accepted by the majority of California botanists places the type as the densely tomentose, non-hispid specimens on the sheet at the Natural History Museum. Specimens of a hispid, non-tomentose form mounted upon the same sheet are interpreted by some to be the northwest coastal form known as *A. columbiana* Piper, and, on the basis of a seeming confusion of the two forms in Pursh's original description and the subsequent treatment of *Arbutus tomentosa* Pursh by Hooker (Bot. Beechey **1:** 144,—1832) and by Lindley (Bot. Reg. **21:**—1836), to be the type. (cf. Abrams, Leafl. West. Bot. **1:** 85–87 (1934)).

Occurring in abundance with the typical form at Monterey are two closely related but distinctive forms commonly included in the broader interpretation of *A. tomentosa*. One of these differs from *A. tomentosa* in having somewhat longer and wider leaves which vary in the nature

of the lower surface from a nearly glabrous to a tomentulose condition, but agrees in all other respects. It is not at all glandular in any part; branchlets are truly tomentose; an enlarged root-crown is produced and the shrubs have the characteristic shreddy bark and general aspect of *A. tomentosa*. In the present treatment it is accorded varietal rank.

The other form, known also from the Santa Lucia Mts., presents a striking difference in character of indument of branchlets and pedicels but in other respects is essentially "tomentosa-like." The relationship of this with *A. tomentosa* seems best expressed by according subspecific rank to this glandular plant.

A striking and invariable character of *A. tomentosa* and its close relatives and of *A. crustacea* is the truncate to subcordate leaf base accompanied by the restriction of the stomata to the lower surface of the leaves. Thus, on the basis of its smooth bark and "glandulosa-like" habit of growth *A. crustacea* might be considered a link of relationship between *A. glandulosa* and *A. tomentosa*.

30a. **Arctostaphylos tomentosa** var. **hebeclada** (Eastw.) comb. n.

Andromeda bracteosa var. *hebeclada* DC. Prodr. **7:** 607 (1839). *Arctostaphylos bracteosa* var. *hebeclada* Eastw. Leafl. West. Bot. **1:** 122 (1934).

Erect shrub with habit and stature of the species; branchlets with a more or less dense tomentulum; leaves varying from oblong or broadly elliptic to long-ovate, 3–5 cm. long, 2–3 cm.wide, truncate or subcordate at base, acute at apex, upper surface glabrous or nearly so, lower surface glabrous, puberulent or tomentulose.

Type locality: "Nova California," *Douglas*.

Range: In open pine woods, near the coast, Monterey Co., Calif.

Representative Specimens: Monterey, *Eastwood 2483* (CA). Carmel, *Adams 1095* (UC). Pacific Grove, *Adams 897* (UC).

30b. **Arctostaphylos tomentosa** subsp. **bracteosa** (Abrams) comb. n.

Andromeda bracteosa var. *trichoclada* DC. Prodr. **7:** 607 (1839). *Arctostaphylos bracteosa* Abrams, Leafl. West. Bot. **1:** 84 (1934).

Erect shrub with habit and stature of the species; old stems with dark shreddy bark; branchlets clothed with conspicuous glandular hairs arising from a rather loose pubescence; leaves bright green, elliptic to broadly ovate, obtuse or acute and mucronate at apex, obtuse or slightly subcordate at base, 2–4 cm. long, 1.5–2.5 cm. wide, upper surface mostly

glabrate or slightly glandular-hairy and pubescent, especially along midrib toward base, lower surface usually very glandular-hairy; petioles short, stout, glandular-hairy; bracts foliaceous, glandular-hairy; pedicels glandular; ovary white-hairy, non-glandular; fruits sparsely white-hairy, non-glandular.

Type locality: "Nova California," *Douglas*.

Range: Monterey Peninsula and adjacent mountains, Calif.

Representative Specimens: Monterey, *J. T. Howell 3026* (CA). Carmel, *Elmer 4694* (UC, SU); *Adams 909* (UC). Point Joe, *Mrs. G. E. Kelly* in July 1932 (CA). Del Monte, *Jepson 5701* (J). Tassajara Springs, *Mrs. G. E. Kelly* in June 1917 (CA).

A large proportion of the tall shrubs in the Monterey area and the adjacent hills belong to this subspecies. Some plants are encountered in the region which are evidently of hybrid origin. In such individuals pronounced glandularity is accompanied by a tomentose condition of the lower leaf surface and of the branchlets which approaches that of the species.

31. **Arctostaphylos nummularia** Gray, Proc. Amer. Acad. Sci. **7:** 366 (1868).

Schizococcus nummularius Eastw. Leafl. West. Bot. **1:** 99 (1934). *Schizococcus nummularius* var. *latifolius* Eastw. Leafl. West. Bot. **2:** 50 (1937), type loc. e. of Point Arena, Mendocino Co., California, *Eastwood & Howell 4459* (CA).

Low mat-like or mound-forming shrub with ascending stems rising 1.5 to 6 cm., or erect and up to 1.2 m. high; branchlets pubescent and white-hairy, densely leafy; leaves dark green, shining, elliptic or ovate or somewhat oblong, conspicuously veiny below, glabrous, the margins entire or ciliate, 1–1.5 cm. long, with rounded or short-acute apex and rounded, truncate or slightly subcordate base; petioles about 2 mm. long, hairy; inflorescence small, with slender glabrous or puberulent rachises and very small scale-like bracts; pedicels glabrous; flower 4-merous, the corolla white, 4–5 mm. long; ovary sparsely hairy; fruit greenish when ripe, oblong, 3–4 mm. long, with thin pericarp, separable into 4 or 5 one-seeded nutlets.

Type locality: Mendocino Plains, Mendocino Co., California, *Bolander*.

Range: Dry flats and pine barrens, 20 to 100 feet. Abundant along central Mendocino Coast, less frequent southward to Sonoma Co., Calif.

Representative Specimens: CALIFORNIA. Mendocino City, pine barrens, *M. E. Jones 29065* (UC); *Jepson 2964* (J). Fort Bragg, *Davy 6563* (UC). Albion, *Davy & Blasdale 6068* (UC). Near McNamee's Station, Sonoma Co., *Adams 832, 827* (UC).

Apparent hybrids between this species and *A. uva-ursi* are frequently found (McNamee's Station, *Adams 823, 826* (UC)). Possible hybrids between this and *A. columbiana* are represented by a collection at Mendocino City, *Eastwood 11458* (CA).

32. **Arctostaphylos sensitiva** Jepson, Madroño **1:** 85, 94 (1922).

Schizococcus nummularius Eastw. Leafl. West. Bot. 1: 99 (1934), in part as to Mt. Tamalpais and Santa Cruz Mts. *Schizococcus sensitivus* Eastw. Leafl. West. Bot. **2:** 50 (1937).

Erect compact shrub with smooth dark red bark, 1 to 2 m. high; branchlets straight, pubescent and long-hairy; leaves dark green, shining, veiny, glabrous, almost rotund to somewhat oblong, short-acute at apex, rounded or truncatish at base, entire or serrulate, 1–2 cm. long and wide, on hairy petioles 2 mm. long; inflorescence with slender glabrous rachises and small scale-like bracts; pedicels glabrous; flower 4-merous, the corolla white, 4 mm. long; ovary sparsely hairy; fruit greenish, oblong, flattened laterally, with very thin pericarp and separable into 2 one-seeded nutlets. No enlarged root-crown is produced and the plants are promptly killed by fire.

Type locality: Southern ridges of Mt. Tamalpais, Marin Co., California, *Jepson 14730* (J).

Range: Dry mountain slopes, 1500 to 2500 feet. Southern Marin Co. and Santa Cruz Mts., Santa Cruz Co., Calif.

Representative Specimens: CALIFORNIA. Marin Co.: Mt. Tamalpais, *Eastwood*, Dist. *C. F. Baker 3241; Adams 875* (UC). Santa Cruz Co.: Hills betw. Butano and Little Butano Cr., *Dudley* (UC, SU); Ben Lomond, *Elmer 4899* (UC, SU); Big Basin, *Adams 811* (UC); near Bonnie Doon, *Wiggins 5093* (UC, SU); Crystal Springs Res., *Dudley* in 1906 (SU).

This species is closely related to *A. nummularia* Gray. Its manner of growth and aspect, however, are very different. *A. sensitiva* is always a dense erect shrub tapering from a broad crown to a narrow base, while the former grows as a distinctive rounded mound with marginal branches decumbent and rooting, or prostrate in exposed situations. It differs also from *A. nummularia* in its flattened fruit.

33. **Arctostaphylos myrtifolia** Parry, Pitt. **1:** 35 (1887).

Arctostaphylos nummularia var. *myrtifolia* Jepson, Madroño **1:** 85, 93 (1922). *Schizococcus myrtifolius* Eastw. Leafl. West. Bot. **1:** 99 (1934).

Low erect diffusely branching shrub with lateral stems frequently decumbent and rooting, .5 to 1 m. high; branches and stems usually very crooked, with dark red bark overlain with a grayish waxy bloom; branchlets with scaly bark and prominent usually glandular rigid hairs; leaves light green, somewhat shining, roughish, elliptic or narrowly ovate, mostly acute and mucronate at apex, obtuse or acute at base, .5–1.5 cm. long, 4–6 mm. wide, on subhispid petioles 2 mm. long; inflorescence small, with slender puberulent rachis and small deltoid bracts; pedicels glabrous; corolla white or pinkish, 4 mm. long; ovary pubescent; fruit greenish, oblong, 4 mm. long, with thin pericarp and separable into 4 or 5 one-seeded nutlets. No enlarged root crown is produced.

Type locality: Ridges east of Ione, Amador Co., California, *Parry*.

Range: Exposed shale ridges, 400 to 800 feet. Foothills between Sutter Cr. and Jackson Cr., Amador Co., Calif.

Representative Specimens: Ione, *Parry* in 1886 (UC); *Adams 800* (UC). Buena Vista, *Jepson 9961* (J).

In the type locality the shrubs show a peculiar deformity of the stems and branches involving a one-sided growth due to the death of the bark on one side (3). This results in the older stems and branches being extremely flattened and presenting a ribbon-like aspect.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

BIBLIOGRAPHY

1. ABRAMS, L. R. 1914. North American Flora **29:** 92–101.
2. ———. 1934. Leaflets of Western Botany **1:** 84–87.
3. ADAMS, J. E. 1934. Madroño **2:** 147–152.
4. ———. 1939. Journal of the Elisha Mitchell Scientific Society **55:** 244.
5. ADANSON, M. 1763. Familles des Plantes **2:** 165.
6. BAKER, M. S. 1932. Leaflets of Western Botany **1:** 31–32.
7. BRITTON, N. L., AND A. BROWN. 1913. Illustrated Flora of the Northern States & Canada, Ed. 2, **2:** 693.
8. DECANDOLLE, A. P. 1839. Prodromus systematis naturalis regni vegetabilis **7:** 607.
9. DESVAUX, A. N. 1813. Journal Bot. Desvaux, II, **1:** 37.
10. DONN, G. 1834. Gen. Syst. **3:** 836.
11. DRUDE, O. 1889. Engler & Prantl, die Pflanzenfamilien 4^1: 48–49.
12. EASTWOOD, A. 1897. Proceedings of the California Academy of Sciences, ser. 3., **1:** 81–85.
13. ———. 1902. Sierra Club Publication **27:** 52.

14. ———. 1905. Bulletin of the Torrey Botanical Club **32**: 201–203.
15. ———. 1905. Sargent, Trees & Shrubs **1**: 203–205.
16. ———. 1931. Proceedings of the California Academy of Sciences, ser. 4., **20**: 149.
17. ———. 1933. Leaflets of Western Botany **1**: 61–63.
18. ———. 1933. Ibid., **1**: 73–80.
19. ———. 1934. Ibid., **1**: 97–100.
20. ———. 1934. Ibid., **1**: 105–127.
21. ———. 1937. Ibid., **2**: 8.
22. ———. 1937. Ibid., **2**: 49–50.
23. FERNALD, M. L., AND J. F. MACBRIDE. 1914. Rhodora **16**: 211–213.
24. ———. 1933. Ibid., **35**: 348–350.
25. GRAY, A. 1868. Proceedings of the American Academy of Sciences **7**: 366.
26. ———. 1876. Botany of the California Geological Survey **1**: 453.
27. ———. 1876. Proceedings of the American Academy of Sciences **11**: 83.
28. ———. 1878. Synoptical Flora of North America **2**: 27–28.
29. GRAY, S. F. 1821. Natural Arrangement of British Plants **2**: 400.
30. GREENE, E. L. 1891. Pittonia **2**: 171–172.
31. ———. 1887. Bulletin of the California Academy of Sciences **2**: 406.
32. HELLER, A. 1913. Muhlenbergia **9**: 68.
33. HEMSLEY, W. B. 1881. Biol. Centr. Am. Bot. **2**: 278.
34. HOOKER, W. J. 1834. Flora Borealis Americae **2**: 36.
35. HOWELL, J. T. 1933. Leaflets of Western Botany **1**: 63–64.
36. ———. 1936. Ibid., **1**: 233–234.
37. ———. 1938. Ibid., **2**: 70–71.
38. HOWELL, THOS. 1901. Flora of Northwest America, pp. 415–417.
39. HUMBOLDT, BONPLAND AND KUNTH. 1819. Nov. Gen. et Sp. **3**: 278.
40. JACKSON, B. D. 1910. Journal of Botany **48**: 206.
41. JEPSON, W. L. 1916. Madroño **1**: 3–11.
42. ———. 1922. Ibid., **1**: 76–86, 88–96.
43. ———. 1925. Manual of the Flowering Plants of California, pp. 744–750.
44. ———. 1931. Proc. Fifth Intern. Bot. Cong., Cambridge, Eng., pp. 114–116.
45. KLOTZSCH, J. F. 1851. Linnaea **24**: 73–81.
46. KUNTZE, O. 1891. Revisio Generum, p. 385.
47. LEMMON, J. G. 1890. Pittonia **2**: 68.
48. LINDLEY, J. 1836. Botanical Register **21**: 1791.
49. LINNAEUS, C. 1753. Species Plantarum, p. 395.
50. MACBRIDE, J. F. 1918. Contributions from the Gray Herbarium **53**: 16.
51. MASON, H. L. 1934. Publ. Carnegie Inst. of Washington, No. 415: 172–174.
52. MERRIAM, C. H. 1918. Proceedings of the Biological Society of Washington **31**: 101–103.
53. MILLER, P. 1754. Gardener's Dictionary, Abr. Ed. 4.
54. NECKER, N. J. 1790. Elem. Bot. **1**: 219.
55. NIEDENZU, F. 1889. Engler, Botanische Jahrb. **11**: 144.
56. ———. 1891. Engler & Prantl, die Pflanzenfamilien 4^1: 48–49.
57. NUTTALL, T. 1843. Transactions of the American Philosophical Society, Ser. 2, **8**: 258, 267–268.

58. PARRY, C. C. 1884. Proceedings of the Davenport Academy of Science **4:** 30–37.
59. ———. 1887. Pittonia **1:** 35.
60. ———. 1888. Bulletin of the California Academy of Sciences **2:** 483–496.
61. PECK, M. E. 1932. Torreya **32:** 151.
62. PIPER, C. V. 1902. Bulletin of the Torrey Botanical Club **29:** 642.
63. ———. 1915. Flora of the Northwest Coast, p. 279.
64. PURSH, F. 1814. Flora Americae Septentrionalis **1:** 282.
65. ROLLINS, R. C. 1937. Rhodora **39:** 462–463.
66. SMALL, J. K. 1914. North American Flora **29:** 85.
67. SMITH, J. D. 1891. Botanical Gazette **16:** 13.
68. ———. 1913. Ibid., **55:** 437.
69. SPRENGEL, K. 1825. Systema **2:** 287.
70. Standley, P. C. 1924. Contributions from the United States National Herbarium **23:** 1094–1098.
71. TOURNEFORT, J. P. 1700. Institutiones, 598, t. 370.
72. WATSON, S. 1871. King, Geological Exploration of the 40th Parallel **4:** 210.
73. WILLIAMS, F. N. 1910. Journal of Botany **48:** 183.
74. ZUCCARINI, J. G. 1837. Abhandlung Akad. Munch. **2:** 331.

A COUNTY CHECK LIST OF NORTH CAROLINA FERNS AND FERN ALLIES

By H. L. Blomquist and D. S. Correll

One Map

Because of its geographical location and topographical features, North Carolina is favorably situated for the development of luxuriance and variety in plant life. It is located in a region of mild climate and an abundant and well distributed rainfall. A wide range of variations in altitude and soil conditions favor a corresponding variety in plant life. Because of this rich and interesting flora, North Carolina has been, since the time of André Michaux, a favorite collecting ground for botanists.

This variety in plant life of North Carolina is well illustrated by its fern flora which, in this respect, is probably not surpassed by any state in the eastern United States except Florida. In the southeastern coastal plain are found such native tropical and subtropical species as *Adiantum Capillus-Veneris*, *Dryopteris ludoviciana*, and such naturalized exotics as *Pteris multifida* and *Lygodium japonicum*. In contrast, one finds in the western or mountainous part of the state several species which range into the arctic regions, such as *Cystopteris fragilis*, *Woodsia ilvensis*, *Lycopodium selago*, *Dryopteris Phegopteris*, and *Dryopteris spinulosa* and its varieties.

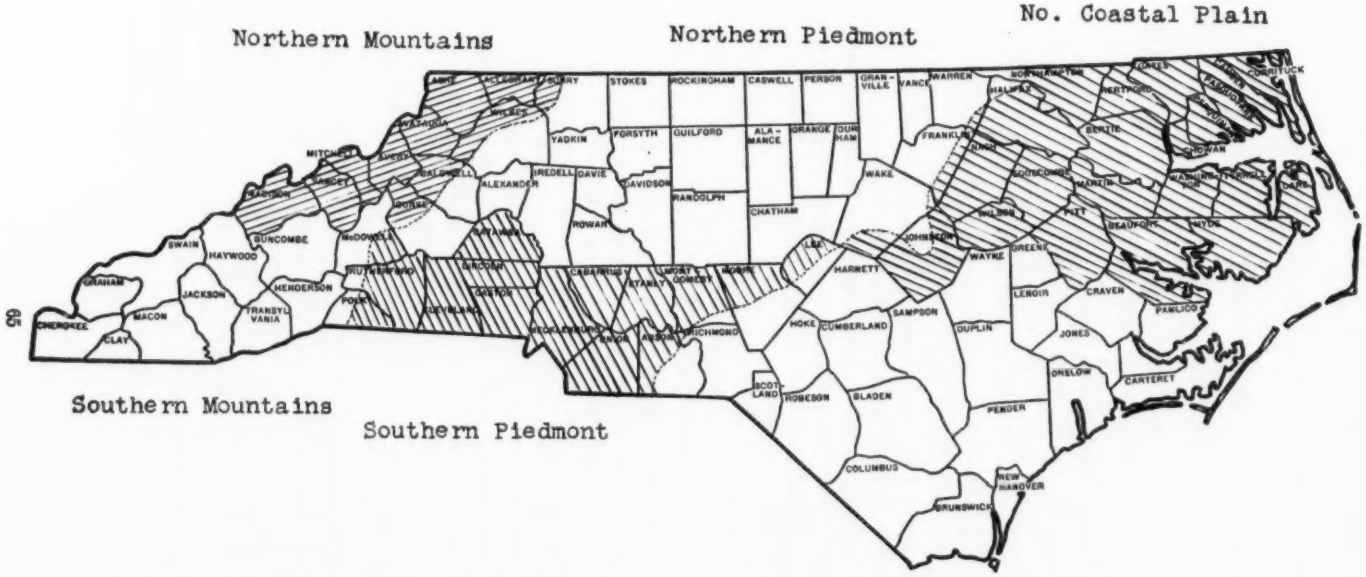
In 1934, Blomquist published a flora of the ferns of North Carolina with illustrations and distributional data so far as they were known at that time. This publication has stimulated considerable interest in the ferns of the state and has led to further collecting, especially in search for new records for the state as well as old records which may have been previously overlooked. The result has been that a few genera and several species not reported by Blomquist have been recorded for the state and the distributional data within the state have been greatly extended. It seems, therefore, highly desirable at this time that the new records for the state as well as the distributional data within the state be revised and brought up to date. This has been the main justification for the preparation of this paper. Another purpose has been to

revise the nomenclature so that it will conform to the latest international rules and to modern concepts of species and varieties.

Blomquist listed 67 species of ferns, one form and four hybrids for North Carolina, making a total of 73 entities. Some of the groups considered by him as species are here reduced to varietal rank. In the present study, 68 species, 13 varieties, 10 forms, and 2 hybrids, making a total of 95 entities, are recorded for the state. For the sake of completeness, several additional segregates are included for which no specimens from the state have been seen but whose area of distribution includes North Carolina. Forms are included not because they are considered worthy of taxonomic rank but because they attract considerable interest and have been recognized and recorded by many authors.

For conservation of space, not all collections seen have been cited. Where it is apparent that several collections have come from the same general locality and from the same county, only one collection is cited. Because of local interest, the collections deposited in the Duke University Herbarium have been cited first. This material has been supplemented by specimens found in other herbaria. In the citation of specimens, the counties are cited by provinces as designated by the U. S. Geological Survey, and, in order to show better the distribution of species, these have been arbitrarily divided into north and south regions (see map 1).

The writers wish to express their sincere appreciation to the various institutions which have coöperated by lending them material for study. They also wish to thank Mr. C. A. Weatherby of the Gray Herbarium, Harvard University, for his assistance in the identification of doubtful material. In citing the specimens examined and included from the various herbaria, initials are used corresponding to the following legend: "B"—Brooklyn Botanic Garden, Brooklyn, N. Y.; "C"—Cornell University, Ithaca, N. Y.; "D"—Duke University, Durham, N. C.; "F"—Field Columbian Museum, Chicago, Ill.; "G"—Gray Herbarium, Harvard University, Cambridge, Mass.; "MBG"—Missouri Botanical Garden, St. Louis, Mo.; "Mich"—University of Michigan, Ann Arbor, Mich.; "Minn"—University of Minnesota, Minneapolis, Minn.; "N"—U. S. National Herbarium, Washington, D. C.; "NC"—University of North Carolina, Chapel Hill, N. C.; "NY"—New York Botanical Garden, New York, N. Y.; "O"—Oberlin College, Oberlin, Ohio; "P"—Philadelphia Academy of Natural Sciences, Philadelphia, Pa.; "Pa"—University of Pennsylvania, Philadelphia, Pa.; "V"—University of Vermont, Burlington, Vermont.



Map. 1. North Carolina. Divided into provinces.

PTERIDOPHYTA

ORDER I. FILICALES

FAMILY 1. HYMENOPHYLLACEAE. Filmy-fern Family

1. TRICHOMANES L. Filmy-ferns

1. **Trichomanes Boschianum** Sturm (Bristle or Killarney Fern). Cavernous places in rock cliffs along streams and moist situations under rock ledges. *Alabama to North Carolina, Ohio, and Illinois.

So. MT. COUNTIES: MACON: Under rocks of falls on right fork (up stream of branch flowing around west side of largest cliffs) just below Cullasaja Falls, July 1938, *H. Heckenbleikner* (NC).

2. **Trichomanes Petersii** A. Gray (Peter's Filmy-fern). On shaded ledges and cliffs where the air is continually moist. Florida to Louisiana, north to North Carolina and Tennessee; also Hispaniola.

So. MT. COUNTIES: GRAHAM: In shady place on siliceous outcrop on north facing slope, margin of Lake Calderwood, Feb. 1939, *A. R. Shields* 4642 (D).

FAMILY 2. POLYPODIACEAE. Fern Family

1. ADIANTUM L. Maidenhair Ferns

1. **Adiantum Capillus-Veneris** L. (Venus'-hair Fern). On marl bluffs and exposures in the eastern part of the state. Florida to Texas, sporadically northward to southern Virginia, Missouri, South Dakota, British Columbia, west to California and Arizona; also escaped but scarcely persisting in Maryland, Pennsylvania, and New York; subtropical regions of both hemispheres.

So. COASTAL PLAIN COUNTIES: COLUMBUS: *Blomquist* 1588 (D); NEW HANOVER: *Canby* (P). Also: Marl bluffs of Cape Fear River, July, *McCarthy* (F).

OLDEST COLLECTION SEEN: NEW HANOVER: near Wilmington, May 1867, *W. M. Canby* (P).

2. **Adiantum pedatum** L. (Northern Maidenhair Fern). In rich humus of woods along streams and on slopes of wooded ravines. Nova Scotia and Quebec to Minnesota, south to Georgia and Florida (?), Oklahoma and Louisiana; also eastern Asia.

No. MT. COUNTIES: ALLEGHANY: *Correll & McDowell* 10816 (D).

* The general distribution data are, for the most part, taken from Broun (1938).

ASHE: *Correll* 3973 (D). AVERY: *Correll & McDowell* 10905 (D). CALDWELL (or Watauga): *Durand* 12894 (C). MADISON: *Pethick* 101 (D).

So. Mt. COUNTIES: BUNCOMBE: *Correll* 228 (D). CHEROKEE: *Correll* 3586 (D). CLAY: *Oosting* 34577 (D). GRAHAM: *Oosting* 34627 (D). HAYWOOD: *Blomquist* 1594 (D). HENDERSON: *Correll* 3244 (D). JACKSON: *Lovell* 7 (D). MACON: *Blomquist* 1592 (D). McDOWELL: *Oosting* 35373 (D). POLK: *Correll* 3222 (D). RUTHERFORD: *Oosting* 34716 (D). SWAIN: *Oosting* 35253 (D). TRANSYLVANIA: *Oosting* 36133 (D).

No. PIEDMONT COUNTIES: BURKE: *Viele* (D). CASWELL: *Wherry* (P). DAVIDSON: *Totten* (NC). DAVIE: *Correll* 2751 (D). DURHAM: *Blomquist* 1590 (D). FORSYTH: *Oosting* 2058 (D). GRANVILLE: *Blomquist & Correll* 7652 (D). ORANGE: *Blomquist* 1591 (D). RANDOLPH: *Correll* 738 (D). SURRY: *Correll* 4937 (D). WAKE: *Oosting* 33191 (D). WILKES: *Blomquist & Anderson* 10033 (D). YADKIN: *Schallert* (D).

So. PIEDMONT COUNTIES: CATAWBA: *Correll* 2814 (D). GASTON: *Blomquist, Correll & Garren* 7770 (D). LINCOLN: *Correll* 2900 (D).

OLDEST COLLECTION SEEN: *Salem, 1812–21, *L. D. von Schweinitz* (P).

2. ANCHISTEA Presl. Chain Ferns

1. **Anchistea virginica** (L.) Presl (Virginia Chain Fern). Swamps and marshes, seepage slopes and thickets, open floodplain woods, pocosins and moist depressions in savannahs. Florida to Texas, north to Long Island, sporadically northward to Nova Scotia and inland to Bruce Peninsula, Ontario and Michigan; also Bermuda.

No. Mt. COUNTIES: BURKE: *Leeds* 824 (P).

So. Mt. COUNTIES: HENDERSON: *Blomquist & Correll* 7710 (D).

No. PIEDMONT COUNTIES: DURHAM: *Blomquist & Correll* (D). FORSYTH: *Wherry* (P). ORANGE: *Coker* (NC).

* According to Schallert (Bartonia, No. 16: 8–12. 1934), the area covered in North Carolina by Schweinitz in his unpublished manuscript, "Flora Salemitana" of 1821, included the following present-day counties: Catawba, Cumberland, Davidson, Davie, Forsyth, Guilford, Iredell, Lincoln, Montgomery, Orange, Randolph, Rowan, Sampson, Stokes, Surry, Wake, Wilkes, and Yadkin, with the possibility of additional adjacent counties. In labelling a specimen "Sal" or "Salem," Schweinitz did not necessarily mean that it came from present-day Forsyth County because at that time Forsyth County as we know it was included in Stokes County. Also, the specimen may have come from any of the other counties included in the "Flora Salemitana." With this in mind, it is not strange that the following citations under the "Oldest collection seen" should include some monticolous and Coastal Plain species from "Salem."

No. COASTAL PLAIN COUNTIES: BEAUFORT: *Blomquist* (D). BERTIE: *Godfrey* 5367 (G). CAMDEN: *Blomquist* 1601 (D). DARE: *Correll* 1728 (D). GATES: *Correll* 2270 (D). HYDE: *Oosting* 42 (D). NASH: *Blomquist* 6740 (D). PITT: *Blomquist* 7741 (D). TYRRELL: *Correll* 1885 (D). WASHINGTON: *Correll* 1920 (D). WILSON: *Blomquist* 7583 (D).

So. COASTAL PLAIN COUNTIES: BLADEN: *Blomquist* 1596 (D). BRUNSWICK: *Blomquist* 1599 (D). COLUMBUS: *Blomquist* 1598 (D). CRAVEN: *Brown* 105 (N). CUMBERLAND: *Bilt. Herb.* 3711C (N). DUPLIN: *Correll* 4829 (D). HARNETT: *Blomquist* 1597 (D). LENOIR: *Correll* 1432 (D). MOORE: *Wherry* (P). PAMLICO: *Randolph* 893 (C). SAMPSON: *Correll* 1284 (D). SCOTLAND: *Smith* (D).

OLDEST COLLECTION SEEN: Grandfather Mt., 1894, *C. Mohr* (N).

3. ASPLENIUM L. Spleenworts

1. **Asplenium Bradleyi** D. C. Eaton (Bradley's Spleenwort). In strongly acid soils of sandstone, gneiss, and granite rock crevices. Georgia, north to New York and Kentucky, west to Oklahoma.

No. PIEDMONT COUNTIES: BURKE (or Cleveland): *Knight* (D). SURRY: *Schweinitz* (P).

So. PIEDMONT COUNTIES: CLEVELAND: *Wherry* (P). GASTON: *Wherry* (D).

OLDEST COLLECTION SEEN: SURRY: Sauratown Mountains, 1812–21, *L. D. von Schweinitz* (P).

2. **Asplenium cryptolepis** Fernald (Wall Rue). On limestone rocks and ledges, occasionally on masonry. Vermont to Michigan, south to Alabama and Arkansas.

No. MT. COUNTIES: MADISON: *Vasey* (P).

So. MT. COUNTIES: BUNCOMBE: *Hulst* (B). MCDOWELL: *Anderson* 4095 (D).

No. PIEDMONT COUNTIES: SURRY: *Schallert* (G).

OLDEST COLLECTION SEEN: In mountains, July 1841, *A. Gray & J. Carey* (G).

3. *X Asplenium Gravesii* Maxon. North Carolina is within the range of this presumable hybrid of *Asplenium Bradleyi* X *pinnatifidum*. However, no collection has been seen from the state. It should be looked for associated with the above species.

4. **Asplenium montanum** Willd. (Mountain Spleenwort). In crevices of shaded or exposed rock ledges and cliffs on non-calcareous rocks.

Central Georgia and Alabama, north to Ohio and New York, locally in Connecticut and Massachusetts; also reported from Michigan.

No. MOUNTAIN COUNTIES: ALLEGHANY: *Correll & McDowell* 10817 (D). ASHE: *Blomquist & Anderson* 9943 (D). AVERY: *Oosting* 35386 (D). BURKE: *Blomquist & Correll* 4708 (D). CALDWELL (or Watauga): *Durand* 12876 (C). MADISON: *Churchill* (G). MITCHELL: *Ashe* (NC). WATAUGA: *Heller* 210 (P). YANCEY: *Holmes* (NC).

So. MT. COUNTIES: BUNCOMBE: *Correll* 7 (D). CHEROKEE: *Averill, Jr.* (G). HAYWOOD: *Rowe, Anderson & Humphreys* 141 (D). HENDERSON: *Holmes* (NC). JACKSON: *Rowe & Humphreys* 167 (D). MACON: *Blomquist* 6736 (D). POLK: *Kimber & Wright* (P). RUTHERFORD: *Smith* (NC). SWAIN: *Blomquist* 1604 (D). TRANSYLVANIA: *Blomquist* 1605 (D).

No. PIEDMONT COUNTIES: FORSYTH (?): *Schweinitz* (P). ORANGE: *Webb* (D). STOKES: *Oosting* 1948 (D). SURRY: *Schallert* 1531 (D).

So. PIEDMONT COUNTIES: GASTON: *Coker* (NC).

OLDEST COLLECTION SEEN: SURRY: Sauratown Mountains, 1812–21, *L. D. von Schweinitz* (P).

5. **Asplenium pinnatifidum** Nutt. (Pinnatifid Spleenwort). In crevices of dry open or partly sheltered non-calcareous rocks. Georgia to Oklahoma, Indiana, and Pennsylvania.

No. MT. COUNTIES: BURKE: *Canby* (F). WILKES: *Correll & McDowell* 10928 (G).

So. MT. COUNTIES: HENDERSON: *Huger* (NY). JACKSON: *Leeds* 16 (P). RUTHERFORD: *Gray* (NY).

No. PIEDMONT COUNTIES: WILKES: *Correll & McDowell* 10954 (D).

OLDEST COLLECTIONS SEEN: RUTHERFORD: Hickory Nut Gap, *Dr. Gray* (NY); "Shaking Bald" Mountain top, July 19, 1878, *C. H. Hall* [specimen similar to that figured by Wherry and Gray in Amer. Fern Journ. **26:** Pl. 9, fig. 12] (B).

6. **Asplenium platyneuron** (L.) Oakes (Ebony Spleenwort). On well-drained rocky wooded slopes, edge of woods and fields, in thickets along fences and on open rocky slopes. Maine and Ontario, south to Florida, west to Iowa and Texas, sporadically to Kansas and Colorado; also South Africa.

No. MT. COUNTIES: ALLEGHANY: *Correll & McDowell* 10829 (D). ASHE: *Correll* 3993 (D). AVERY: *Correll & McDowell* 10901 (D). BURKE: *Blomquist & Correll* 4711 (D). MADISON: *Trentham* (D). MITCHELL: *Ashe* (NY). WATAUGA: *Heller* 211 (P). WILKES: *Correll & McDowell* 10932 (D). YANCEY: *Wherry* (P).

So. Mt. Counties: Buncombe: *Teague* (D). Clay: *Oosting* 34578 (D). Graham: *Oosting* 34628 (D). Haywood: *Blomquist* 1614 (D). Henderson: *Blomquist* (D). Jackson: *Leeds* 446 (P). Macon: *Holland* (NC). McDowell: *Oosting* 35382 (D). Polk: *Peattie* 661 (NC). Rutherford: *Oosting* 34718 (D). Swain: *Blomquist* 1612 (D).

No. Piedmont Counties: Alexander: *Anderson* (D). Burke: *Viele* (D). Caswell: *Correll & McDowell* 10636 (D). Chatham: *Correll* 717 (D). Davidson: *Correll* 771 (D). Davie: *Correll* 2771 (D). Durham: *Smith* (D). Forsyth: *Schallert* 864 (D). Granville: *Correll* 517 (D). Guilford: *Matthews & Ward* (NC). Orange: *Oosting* 3366 (D). Person: *Blomquist* 1609 (D). Randolph: *Correll* 662 (D). Rockingham: *Oosting* 33402 (D). Rowan: *Beck* 4 (D). Stokes: *Oosting* 1946 (D). Surry: *Blomquist* 6620 (D). Vance: *Wherry* (P). Wake: *Blomquist* 1608 (D). Warren: *Godfrey* 3625 (G). Yadkin: *Oosting* 2056 (D).

So. Piedmont Counties: Anson: *Correll* 7097 (D). Cabarrus: *Blomquist* 1613 (D). Catawba: *Correll* 2847 (D). Gaston: *Correll* 2940 (D). Mecklenburg: *Blomquist, Correll & Garren* 7764 (D). Montgomery: *Oosting* 1894 (D). Moore: *Wherry* (P). Stanly: *Oosting* 1852 (D). Union: *Correll* 980 (D).

No. Coastal Plain Counties: Beaufort: *Blomquist* (D). Bertie: *Correll* 1967 (D). Camden: *Wherry* (P). Edgecombe: *Leeds* 3153 (P). Franklin: *Blomquist* 6601 (D). Hertford: *Correll* 2295 (D). Hyde: *Oosting* 24 (D). Johnston: *Mitchell* (D). Martin: *Correll* 1877 (D). Nash: *Leeds* 3587 (P). Pasquotank: *Godfrey* 5335 (G). Perquimans: *Blomquist* 1607 (D). Pitt: *Correll* 1410 (D).

So. Coastal Plain Counties: Brunswick: *Blomquist* 1615 (D). Carteret: *Ashe* (NC). Craven: *Leeds* 10 (P). Greene: *Correll* 1364 (D). Harnett: *Correll* 373 (D). Jones: *Beaven* 526 (D). Lee: *Blomquist* 1606 (D). Lenoir: *Correll* 1433 (D). Moore: *Correll* 7002 (D). New Hanover: *Schallert* (NC). Onslow: *Leeds* 515 (P). Wayne: *Correll & Blomquist* 4807 (D).

Oldest collection seen: Salem, 1812–21, *L. D. von Schweinitz* (P).

6a. **Asplenium platyneuron** forma **Hortonae** (Davenp.) L. B. Smith. Northern part of the range. This is one of the most attractive forms found among our ferns. It is distinguished from the species by its deeply pinnatifid pinnae which are broadly oblong, and is, as far as we know, always sterile.

No. Piedmont Counties: Durham: On exposed rocks along the Eno River at Guess Road Bridge, Nov. 7, 1937, *Correll* 8571 (D).

6b. **Asplenium platyneuron** forma **incisum** (E. C. Howe) comb. nov. (*Asplenium ebeneum* var. *incisum* E. C. Howe ex Peck, Ann. Rep. Regents Univ. N. Y. **22:** 104. 1869; *Asplenium ebeneum* var. *bacculum-rubrum* Featherman, Rep. Bot. Surv. So. Centr. La. 1870: 75. 1871; *Asplenium ebeneum* var. *serratum* E. S. Miller, Bull. Torr. Bot. Club **4:** 41. 1873). Plants found mainly in the southern part of the range having narrowly elongate and prominently serrate pinnae are included in this form. This form is largely a response to habitat conditions.

No. PIEDMONT COUNTIES: DURHAM: Tomlinson's Place, July 7, 1936, *Blomquist* 7853 (D).

OLDEST COLLECTION SEEN: BURKE: Sallies' Ridge, north of Piedmont Springs, 1891, *J. K. Small & A. A. Heller* (F).

6c. **Asplenium platyneuron** forma **furcatum** Clute. This teratological form, based on the frond being repeatedly branched at the tip, was found at Asheville, N. C., by Miss Frances M. Wright according to Clute (Fern Bull. **17:** 89. 1909).

7. **Asplenium resiliens** Kunze (Black-stem Spleenwort). On shaded or exposed limestone rocks. Arizona through Texas, Kansas, and Missouri to Florida and Pennsylvania; also West Indies, Mexico, and Central America to the Andean region of South America.

No. MT. COUNTIES: MADISON: *Anderson & Wherry* (D). MITCHELL: *Chickering, Jr.* (F).

So. MT. COUNTIES: MCDOWELL: *Oosting* 35381 (D). SWAIN: *Oosting* 35278 (D). TRANSYLVANIA: *Oosting* 36107 (D).

No. PIEDMONT COUNTIES: YADKIN: *Oosting* 2031 (D).

So. PIEDMONT COUNTIES: STANLEY: *Small & Heller* 448 (G).

OLDEST COLLECTION SEEN: MADISON: Warm Springs, Sept. 23, 1876, *J. H. Redfield* (MBG).

8. **Asplenium Trichomanes** L. (Maidenhair Spleenwort). On the shaded side of rocks and cliffs in the vicinity of streams, usually associated with mosses and liverworts. Nova Scotia to Alaska, south to Georgia, Florida (?), Louisiana, Texas, and Arizona; also in Europe and Asia.

No. MT. COUNTIES: ALLEGHANY: *Correll & McDowell* 10828 (D). ASHE: *Correll* 3972 (D). AVERY: *Correll & McDowell* 10908 (D). CALDWELL (or Watauga): *Atkinson* 12869 (C). MADISON: *Trentham* (D). MITCHELL: *Ashe* (NC). WATAUGA: *Durand* 12873 (C). WILKES: *Correll & McDowell* 10930 (D).

So. MT. COUNTIES: BUNCOMBE: *Correll* 85 (D). HAYWOOD: *Blomquist* 1620 (D). HENDERSON: *Blomquist* 1617 (D). JACKSON: *Leeds*

(P). MACON: *Holland* (D). MCDOWELL: *Correll & Blomquist* 4691 (D). POLK: *Correll* 3240 (D). RUTHERFORD: *Wherry* (P). SWAIN: *Oosting* 35266 (D). TRANSYLVANIA: *Oosting* 36117 (D).

NO. PIEDMONT COUNTIES: BURKE: *Wherry* (P). FORSYTH: *Oosting* 2057 (D). ORANGE: *Correll* 4912 (D). ROCKINGHAM: *Correll & McDowell* 10707 (D). STOKES: *Schallert* 2605 (D). SURRY: *Correll & McDowell* 10783 (D). YADKIN: *Blomquist & Anderson* 10043 (D).

SO. PIEDMONT COUNTIES: MONTGOMERY: *Oosting* 1895 (D). STANLY: *Oosting* 1898 (D).

OLDEST COLLECTIONS SEEN: FORSYTH: 1812–21, *L. D. von Schweinitz* (P); Broad River, June 1841, *Rugel* (MBG).

9. X **Asplenium Trudelli** Wherry (Trudell's Spleenwort). Shaded crevices in cliffs of non-calcareous rocks, found with colonies of *A. montanum* and *A. pinnatifidum* which are supposed to be its parents. Alabama to Ohio, Pennsylvania, and New Jersey.

SO. MT. COUNTIES: JACKSON: Cliffs, on wooded hillside, ½ mile northwest of Glenville, Oct. 24, 1933, *A. N. Leeds* 761 (P).

4. X ASPLENOSORUS Wherry

1. X **Asplenosorus ebenoides** (R. R. Scott) Wherry (*Asplenium ebenoides* R. R. Scott) (Scott's Spleenwort). In crevices of shaded rocks in deep woods along streams. Associated with colonies of *A. platyneuron* and *Camptosorus rhizophyllus*, of which it is a hybrid. Vermont, south to North Carolina, Alabama, and Missouri.

SO. MT. COUNTIES: RUTHERFORD: *Blomquist & Correll* 7783 (D).

OLDEST COLLECTION SEEN: RUTHERFORD: On rocks at Hickory Mt. Gap, 1932, *L. P. Breckenridge* (V).

5. ATHYRIUM Roth. Lady-ferns

1. **Athyrium asplenioides** (Michx.) Eat. (Lowland Lady Fern). In moist soil of woods, thickets and stream banks and in swamps. Florida, north to Massachusetts, west to Texas and Missouri.

NO. MT. COUNTIES: ALLEGHANY: *Correll & McDowell* 10822 (D). ASHE: *Correll* 4039 (D). AVERY: *Trudell* (P). MADISON: *Oosting* 34481 (D). WATAUGA: *Small & Heller* (NY). YANCEY: *Holmes* (NC).

SO. MT. COUNTIES: BUNCOMBE: *Correll* 3 (D). CHEROKEE: *Oosting* 34615 (D). CLAY: *Oosting* 34600 (D). GRAHAM: *Correll* 3687 (D). HAYWOOD: *Blomquist* 1630 (D). HENDERSON: *Oosting* 35472 (D). JACKSON: *Blomquist* 1635 (D). MACON: *Holland* (D). MCDOWELL: *Rowe & Humphreys* 106 (D). POLK: *Correll* 3185 (D). RUTHERFORD:

Blomquist & Correll 7793 (D). SWAIN: *Rowe & Humphreys* 155 (D). TRANSYLVANIA: *Blomquist* 1628 (D).

NO. PIEDMONT COUNTIES: BURKE: *Viele* 16 (D). CALDWELL: *Harper* (NC). CASWELL: *Correll & McDowell* 10681 (D). CHATHAM: *Correll* 709 (D). DAVIDSON: *Totten* (NC). DAVIE: *Wherry* (P). DURHAM: *Blomquist* 1631 (D). FORSYTH: *Chitty* (D). GRANVILLE: *Blomquist & Correll* 7654 (D). GUILFORD: *Mitchell* (D). JOHNSTON: *Blomquist* 6280 (D). ORANGE: *Matthews* (NC). PERSON: *Wherry* (P). RANDOLPH: *Correll* 742 (D). ROCKINGHAM: *Oosting* 33406 (D). ROWAN: *Correll* 2788 (D). STOKES: *Correll & McDowell* 10726 (D). SURRY: *Correll* 4943 (D). WAKE: *Stites* 67 (D). WARREN: *Scholz* (D). WILKES: *Blomquist & Anderson* 10040 (D). YADKIN: *Oosting* 2030 (D).

SO. PIEDMONT COUNTIES: CATAWBA: *Correll* 2815 (D). CLEVELAND: *Correll* 2973 (D). GASTON: *Oosting* 1733 (D). LINCOLN: *Correll* 2897 (D). MONTGOMERY: *Correll* 813 (D). MOORE: *Wherry* (P).

NO. COASTAL PLAIN COUNTIES: BEAUFORT: *Correll* 1544 (D). BERTIE: *Correll* 1942 (D). CAMDEN: *Correll* 2072 (D). EDGECOMBE: *Correll* 2451 (D). HALIFAX: *Correll* 2399 (D). HERTFORD: *Leeds* 3122 (P). HYDE: *Godfrey* 4389 (G). PASQUOTANK: *Godfrey* 5334 (G). PERQUIMANS: *Blomquist* 1634 (D). PITT: *Correll* 1404 (D). TYRRELL: *Correll* 1810 (D). WASHINGTON: *Correll* 1919 (D). WILSON: *Oosting* 35614 (D).

SO. COASTAL PLAIN COUNTIES: COLUMBUS: *Reed* 120 (D). CUMBERLAND: *McCarthy* (N). HARNETT: *Godfrey* 4227 (D). LENOIR: *Reed* (D). MOORE: *Correll* 7000 (D). ONSLOW: *Godfrey* 4494 (G). PENDER: *Godfrey* 6584 (G). SCOTLAND: *Godfrey* 5078 (D). WAYNE: *Blomquist* 1632 (D).

OLDEST COLLECTION SEEN: Salem, 1812–21, *L. D. von Schweinitz* (P).

1a. **Athyrium asplenioides** forma **subtripinnatum** Butters. Plants found from North Carolina to Massachusetts with triangular-lanceolate pinnules which are cut into oblong obtuse lobes.

NO. MT. COUNTIES: ASHE: *Correll & McDowell* 10891 (D).

SO. MT. COUNTIES: HAYWOOD: *Lovett* 90 (O). MACON: *Holland* (D).

NO. PIEDMONT COUNTIES: YADKIN: *Correll & McDowell* 10972 (D).

SO. PIEDMONT COUNTIES: MECKLENBURG: *Gray* (D).

2. **Athyrium pycnocarpon** (Spreng.) Tidestr. (Narrow-leaved Spleenwort, Glade Fern). In muddy seepage of cool wooded ravines, rich moist woods and shaded alluvial flats. Maine and Quebec to Wisconsin, south to Georgia, Louisiana, and Kansas.

No. Mt. Counties: Caldwell (or Watauga): *Durand* 12878 (C). Madison: *Wehmeyer* 696 (Mich).

So. Mt. Counties: Haywood: *Holmes* (NC). Polk: *Wherry* (D).

Oldest collection seen: Salem, 1812–21, *L. D. von Schweinitz* (P).

3. **Athyrium thelypteroides** (Michx.) Desv. (Silvery Spleenwort). Densely wooded ravines and on edges of streams, on banks and in rock crevices. Nova Scotia to Minnesota, south to Georgia, Missouri and Texas (?); also eastern Asia.

No. Mt. Counties: Alleghany: *Correll & McDowell* 10819 (D). Ashe: *Correll* 4038 (D). Avery: *Correll & McDowell* 10913 (D). Caldwell (or Watauga): *Durand* 12893 (C). Watauga: *Coker* (NC). Wilkes: *Oosting* 33487 (D).

So. Mt. Counties: Buncombe: *Leeds* 858 (P). Haywood: *Blomquist* 1636 (D). Jackson: *Blomquist* 1621 (D). Macon: *Correll* 6680 (D). Polk: *Blomquist, Correll & Garren* 7842 (D). Swain: *Harbison* (D). Transylvania: *Oosting* 36136 (D).

No. Piedmont Counties: Orange: (1904)—(NC).

Oldest collection seen: Salem, 1812–21, *L. D. von Schweinitz* (P).

6. Camptosorus Link. Walking Ferns

1. **Camptosorus rhizophyllus** (L.) Link (Walking Fern). On shaded ledges of various types of rocks and in shallow humus on rocks in woods, rarely at the base of trees or on rotten logs. Quebec to Minnesota, south to central Georgia, Mississippi, Arkansas, and eastern Oklahoma.

No. Mt. Counties: Ashe: *Correll & McDowell* 10881 (D). Madison: *Blomquist* 1647 (D). Mitchell: *Ashe* (NY).

So. Mt. Counties: Buncombe: *Correll* 4 (D). Haywood: *Blomquist* 1646 (D). Henderson: *Holmes* (NC). Jackson: *Oosting* 34494 (D). Macon: *Harbison* (NC). McDowell: *Oosting* 35358 (D). Polk: *Townsend* 8 (C). Rutherford: *Blomquist & Correll* 7799 (D). Swain: *Oosting* 35272 (D). Transylvania: *Matthews* (NC).

No. Piedmont Counties: Durham: *Blomquist* 7299 (D). Forsyth: *Schallert* 3042 (D). Iredell: *Hyams* (O). Stokes: *Schallert* (G). Yadkin: *Schallert* (D).

Oldest collection seen: Salem, 1812–21, *L. D. von Schweinitz* (P).

1a. **Camptosorus rhizophyllus** forma **auriculatus** Clute. Plants found throughout the range with at least some of the fronds with the basal lobes elongate, attenuate, and often rooting at their tips.

No. Piedmont Counties: Rockingham: *Correll & McDowell* 10700 (D).

7. CHEILANTHES Sw. Lip-ferns

1. **Cheilanthes alabamensis** (Buckley) Kunze (Alabama Lip Fern). In crevices of exposed or sheltered limestone rocks. Florida (?) and Alabama, north to Virginia, west to Missouri, Texas, and Arizona; also Mexico.

No. Mt. Counties: Madison: *Oosting and Anderson* 34312 (D).

So. Mt. Counties: Transylvania (?): *Oosting* 36113 (D).

Oldest collection seen: Madison: Hot Springs, July 26–30, 1880, *J. D. Smith* (G).

2. **Cheilanthes lanosa** (Michx.) D. C. Eaton (Hairy Lip Fern). On non-calcareous rock ledges and rocky slopes, usually with a southern exposure. Connecticut and New York to Georgia, Kansas, Louisiana, and Texas.

No. Mt. Counties: Burke: *Curtis* (P). Madison: *Redfield* (P). Mitchell: *Hyams* (NC).

So. Mt. Counties: Buncombe: *Teague* (D). Haywood: *Blomquist* 1650 (D). Jackson: *Williamson* (P). Polk: *Townsend* 4 (C). Rutherford: *Wherry* (P). Swain: *Beardslee & Kofoid* (G).

No. Piedmont Counties: Alamance: *Causey* (NC). Durham: *Blomquist* 1649 (D). Guilford: *Hall* (D). Orange: *Oosting* 33248 (D). Rowan: *Small* (G). Surry: *Schallert* (G). Wake: *Godfrey* 3982 (G). Wilkes: *Blomquist & Anderson* 10031 (D).

So. Piedmont Counties: Montgomery: *Oosting* 1893 (D). Stanly: *Oosting* 1896 (D).

Oldest collection seen: "North Carolina, 1842," *M. A. Curtis* (MBG).

3. **Cheilanthes tomentosa** Link (Woolly Lip Fern). On open dry rock ledges and slopes freely exposed to the wind and sun. Georgia, north to West Virginia, west to Arkansas, Texas, Arizona, and northern Mexico.

No. Mt. Counties: Madison: *Anderson & Wherry* (D).

So. Mt. Counties: Buncombe: *Faxon* (G). Cherokee: *Averill* (G). Polk: *Wherry* (P). Rutherford: *Ashe* 106 (NC). Swain: *Beardslee & Kofoid* (G). Transylvania: *Oosting* 36114 (D).

No. Piedmont Counties: Orange: *Blomquist* 1652 (D). Rowan: *Wherry* (P). Stokes: *Schallert* 5211 (D). Wilkes: *Blomquist* 10031a (D).

So. Piedmont Counties: Cleveland: *Wherry* (P). Lincoln: *Hunter* (G). Montgomery: *Oosting* 1892 (D). Stanly: *Oosting* 1897 (D).

OLDEST COLLECTIONS SEEN: MADISON: French Broad River, Painted Rock, 1843, [*Rugel*?] (G). WILKES: 1812–21, *L. D. von Schweinitz* (P).

8. CYSTOPTERIS Bernh. Bladder Ferns

1. **Cystopteris bulbifera** (L.) Bernh. (Bulblet Bladder Fern). On shaded ledges and in cool rock crevices of limestone. Newfoundland to Manitoba, south to Georgia and southwest to Arizona and New Mexico.

No. MT. COUNTIES: MADISON: *Oosting* 35305 (D).

So. MT. COUNTIES: SWAIN: *Blomquist, Anderson & Smith* 1654 (D).

OLDEST COLLECTION SEEN: Salem, 1812–21, *L. D. von Schweinitz* (P).

2. **Cystopteris fragilis** (L.) Bernh. (Brittle or Fragile Fern). This is a polymorphic and extremely variable species in which a number of forms and varieties are recognized. The species is rare in North Carolina. Nearly all of the specimens examined have been referred to one or the other of the following varieties. However, because of the intergradation of the characters separating these two varieties, determinations were in many instances more or less arbitrary.

No. MT. COUNTIES: AVERY: *Wherry* (P). WATAUGA: *Leeds* 58 (P).

OLDEST COLLECTION SEEN (as var. *protrusa*): Salem, 1812–21, *L. D. von Schweinitz* (P).

2a. **Cystopteris fragilis** var. **Mackayii** Lawson. In crevices of moist cliffs and sheltered ledges, rich mossy wooded slopes. Quebec, through New England to the mountains of North Carolina, west to Wisconsin, South Dakota, and Missouri.

So. MT. COUNTIES: HAYWOOD: *Anderson* 1425 (P). MACON: *Wherry* (P). POLK: *Wherry* (P).

2b. **Cystopteris fragilis** var. **protrusa** Weatherby. Variety *protrusa* is rather common and widespread in North Carolina. It is the common variety in the southeastern states; ranging from Alabama to Louisiana and Arkansas, north to New York and Minnesota. It is found on rocky wooded slopes, in rock crevices and along stream banks.

No. MT. COUNTIES: ALLEGHANY: *Correll* 10821 (D). ASHE: *Correll* 3975 (D). MADISON: *Rogers* 60 (D). MITCHELL: *Smith* (N). WATAUGA: *Churchill* (G).

So. MT. COUNTIES: BUNCOMBE: *Correll* 10 (D). HAYWOOD: *Blomquist* 1657 (D). JACKSON: *Blomquist* 1655 (D). MACON: *Holland* (D). McDOWELL: *Blomquist & Correll* 4692 (D). POLK: *Correll* 3228 (D).

RUTHERFORD: *Blomquist & Correll* 7784 (D). SWAIN: *Blomquist* 1656 (D). TRANSYLVANIA: *Oosting* 36134 (D).

NO. PIEDMONT COUNTIES: FORSYTH: *Schallert* 1005 (D). LINCOLN: *Hyams* (O). YADKIN: *Correll & McDowell* 10964 (G).

9. DENNSTAEDTIA Bernh. Hay-scented Ferns

1. **Dennstaedtia punctilobula** (Michx.) Moore (Hay-scented Fern). Moist shaded woods, dry open woods and rocky slopes, and upland pastures where it becomes a troublesome weed if over-grazing occurs. Nova Scotia to Minnesota, south to Georgia, Missouri, and Arkansas.

NO. MT. COUNTIES: ALLEGHANY: *Blomquist & Anderson* 9921 (D). ASHE: *Correll* 3983 (D). AVERY: *Rowe & Humphreys* 119 (D). BURKE: *Rowe & Humphreys* 112 (D). CALDWELL: *Small & Heller* (G). MADISON: *Rogers* 61 (D). MITCHELL: *Hyams* (NC). WATAUGA: *Small & Heller* (C). WILKES: *Correll & McDowell* 10933 (D).

SO. MT. COUNTIES: BUNCOMBE: *Correll* 229 (D). CHEROKEE: *Correll* 3588 (D). CLAY: *Oosting* 34580 (D). GRAHAM: *Oosting* 34629 (D). HAYWOOD: *Blomquist* 1653 (D). HENDERSON: *Oosting* 35468 (D). JACKSON: *Blomquist* 1660 (D). MACON: *Holland* (D). MCDOWELL: *Rowe & Humphreys* 111 (D). POLK: *Townsend* 14 (C). RUTHERFORD: *Oosting* 34717 (D). SWAIN: *Blomquist* 1661 (D). TRANSYLVANIA: *Lovett* 24 (D).

NO. PIEDMONT COUNTIES: BURKE: *Wherry* (P). STOKES: *Oosting* 1952 (D). SURRY: *Correll & Oosting* 4917 (D).

SO. PIEDMONT COUNTIES: CATAWBA: *Wherry* (P). GASTON: *Coker* (NC). MONTGOMERY: *Oosting* 1877 (D).

OLDEST COLLECTION SEEN: MACON: 1842, *Rugel* (N).

10. DRYOPTERIS Adans. Shield Ferns

Many of the species of the southeastern *Dryopteris* are by no means easy to determine, particularly those found in the *Dryopteris spinulosa* and varieties, *D. cristata* and varieties, and *D. normalis-dentata* complexes. Students of North Carolina ferns are fortunate not to have the latter complex in the state. However, the other two complexes provide problems enough for both the beginner and the professional botanist.

1. *Dryopteris Boottii* (Tuckerm.) Underw. (Boott's Shield Fern). According to Small (1938, p. 267) North Carolina is in the range of this species. However, we have seen no specimens from the state.

2. **Dryopteris celsa** (W. Palmer) Knowlton, Palmer & Pollard (Log Fern). We have included under this, the oldest name, a group of plants

which have been insufficiently studied and are, at present, little known. Several species and varieties have been described for these plants, among which may be mentioned *Dryopteris atropalustris* Small, *D. cristata* var. *australis* Wherry and *D. separabilis* Small. Variations, particularly in leaf form and in the position of the sori, are no greater in this group than those allowed in other species of *Dryopteris*. However, the various concepts which have been proposed are based mainly on such minor variations, without any apparent effort to coordinate or contrast, as a whole, this group of plants.

Plants of this concept have been found locally from Arkansas and Louisiana along the Gulf and Atlantic Coastal Plain and foothills of the Appalachian Mountains to Pennsylvania. It is most often found in swampy woods and densely wooded ravines, and is seldom found in great abundance although it is plentiful at several of the stations found in Virginia.

Dryopteris celsa is most closely allied to *D. ludoviciana* and *D. cristata*. However, some extreme forms approach *D. cristata* var. *Clintoniana* and *D. Goldiana*. The species is not only poorly represented in herbaria, but is in need of intensive research and revision. Because of this, we have deemed it wise to segregate the North Carolina specimens under *D. celsa*, the oldest name in this group. We have been aided by Mr. Weatherby in arriving at this conclusion.

No. PIEDMONT COUNTIES: ORANGE: June 1, 1888, *J. S. Holmes* (NC).

So. PIEDMONT COUNTIES: MECKLENBURG: 9 miles north of Charlotte, Sept. 11, 1936, *F. W. Gray* (P).

3. **Dryopteris cristata** (L.) A. Gray (Crested Shield Fern). In marshes, boggy thickets and springy wooded slopes. Newfoundland to Idaho, south to North Carolina and Arkansas: also Europe.

No. MT. COUNTIES: MADISON: *Oosting* 34480 (D). MITCHELL: *Hyams* (NC). WATAUGA: *Blomquist* 10783 (D).

No. PIEDMONT COUNTIES: DURHAM: *Blomquist* 1662 (D). ORANGE: *Totten* (NC).

So. PIEDMONT COUNTIES: MECKLENBURG: *Gray* (D).

OLDEST COLLECTION SEEN: MECKLENBURG: Oct. 1927, *Fred Gray* (D).

3a. *Dryopteris cristata* var. *Clintoniana* (D. C. Eaton) Underw. (*D. Clintoniana* (D. C. Eaton) Dowell) (Clinton's Shield Fern). This variety is found in wet woods, swamps and thickets along streams from Quebec and Wisconsin to the mountains of Georgia. However, no specimens were seen from North Carolina. The specimen cited by Blomquist (1934, p. 63) has been relegated to *D. celsa*.

4. **Dryopteris Goldiana** (Hook.) A. Gray (Goldie's Shield Fern). Moist rocky wooded ravines and along cool wooded mountain streams. New Brunswick to Minnesota and Iowa, south to southeastern Virginia and the mountains of North Carolina and Tennessee.

No. Mt. Counties: Avery: *Trudell* (P). Caldwell (or Watauga): *Durand* 12872 (C). Madison: *Knight* (N).

So. Mt. Counties: Buncombe: *Correll* 12 (D). Haywood: *Rowe & Humphreys* 144 (D). Swain: *Beardslee & Kofoid* (G).

Oldest collection seen: Swain: Alt. 3500 ft., Aug. 15, 1891, *H. C. Beardslee & C. A. Kofoid* (G).

5. **Dryopteris hexagonoptera** (Michx.) C. Chr. (Broad Beech Fern). Rich wooded slopes, open rocky thickets and on the edge of low swampy woods. Texas to Florida, north to Minnesota and Quebec.

No. Mt. Counties: Alleghany: *Correll & McDowell* 10812 (D). Ashe: *Correll* 4041 (D). Avery: *Wherry* (P). Madison: *Trentham* (D).

So. Mt. Counties: Buncombe: *Correll* 227 (D). Cherokee: *Correll* 3587 (D). Clay: *Oosting* 34581 (D). Graham: *Correll* 3688 (D). Haywood: *Pethick* 13 (D). Henderson: *Correll* 3249 (D). Jackson: *Blomquist* 1671 (D). Macon: *Correll* 3518 (NY). McDowell: *Leeds* 419 (P). Polk: *Correll* 3223 (D). Swain: *Beardslee & Kofoid* [*specimen bifurcate at the apex*] (O). Transylvania: *Oosting* 36132 (D).

No. Piedmont Counties: Caswell: *Correll & McDowell* 10637 (D). Davie: *Correll* 2752 (D). Forsyth: *Schallert* 1017 (D). Granville: *Blomquist & Correll* 7657 (D). Guilford: *Mitchell* (D). Iredell: *Hyams* (O). Orange: *Avery* (D). Randolph: *Correll* 735 (D). Stokes: *Correll & McDowell* 10723 (D). Surry: *Oosting* 3530 (D). Wake: *Blomquist* 1670 (D). Wilkes: *Blomquist & Anderson* 10037 (D). Yadkin: *Correll & McDowell* 10967 (D).

So. Piedmont Counties: Gaston: *Blomquist, Correll & Garren* 7769 (D).

No. Coastal Plain Counties: Beaufort: *Blomquist* 7960 (D). Bertie: *Correll* 1972 (D). Tyrrell: *Correll* 1805 (D).

So. Coastal Plain Counties: Pender: *Godfrey* 6589 (G).

Oldest collection seen: Salem, 1812–21, *L. D. von Schweinitz* (P).

6. **Dryopteris ludoviciana** (Kunze) Small (*D. floridana* (Hook.) Kuntze) (Louisiana or Florida Shield Fern). In cypress and gum swamps, wet thickets and along streams. Florida along the coast to North Carolina, Louisiana, and Texas (?).

So. Coastal Plain Counties: Columbus: *Blomquist & Correll* 7625 (D). Craven: *Oosting* 2072 (D).

Oldest collection seen: Columbus: Lake Waccamaw, April 7, 1931, *J. E. Benedict, Jr.* 1247 (P).

7. **Dryopteris marginalis** (L.) A. Gray (Marginal Shield Fern). On rocks and shaded ledges along wooded streams and on rocky wooded slopes. Nova Scotia to Minnesota, south to Alabama, Mississippi, and Oklahoma; also isolated in British Columbia.

No. Mt. Counties: Alleghany: *Correll & McDowell* 10818 (D). Ashe: *Correll* 3970 (D). Avery: *Correll & McDowell* 10897 (D). Caldwell: *Small & Heller* 487 (P). Madison: *Rogers* 54 (D). Mitchell: *Ashe* (NY). Watauga: *Durand* 12884 (C).

So. Mt. Counties: Buncombe: *Teague* (D). Clay: *Wherry* (P). Graham: *Oosting* 34625 (D). Haywood: *Lovett* 78 (D). Henderson: *Blomquist* 1680 (D). Jackson. *Blomquist* 1681 (D). Macon: *Oosting* 34436a (D). McDowell: *Leeds* 413 (P). Polk: *Peattie* 1561 (NC). Rutherford: *Oosting* 34715a (D). Swain: *Blomquist* 1682 (D). Transylvania: *House* 3689 (G).

No. Piedmont Counties: Durham: *Blomquist* 1683 (D). Rockingham: *Correll & McDowell* 10697 (D). Surry: *Correll* 4933 (D). Wilkes: *Blomquist & Anderson* 10019 (D). Yadkin: *Schallert* (D).

So. Piedmont Counties: Stanly: *Oosting* 1853 (D).

Oldest collection seen: Salem, 1812–21, *L. D. von Schweinitz* (P).

8. **Dryopteris noveboracensis** (L.) A. Gray (New York Shield Fern). Low shaded woods, thickets and edge of swamps in moderately acid soil. Newfoundland to Minnesota, south to Georgia, Arkansas, and Texas (?).

No. Mt. Counties: Alleghany: *Blomquist & Anderson* 9913 (D). Avery: *Correll* 3956 (D). Burke: *Rowe & Humphreys* 113 (D). Caldwell: (1914)—(NC). Madison: *Oosting* 34482 (D). Mitchell: *Rowe & Humphreys* 121 (D). Watauga: *Durand* 12886 (C). Wilkes: *Correll & McDowell* 10949 (D).

So. Mt. Counties: Buncombe: *Correll* 23 (D). Cherokee: *Oosting* 34616 (D). Clay: *Oosting* 34582 (D). Haywood: *Blomquist* 1684 (D). Henderson: *Oosting* 35473 (D). Jackson: *Blomquist* 1687 (D). Macon: *Holland, et al.* (D). McDowell: *Rowe & Humphreys* 103 (D). Polk: *Peattie* 1211 (NC). Rutherford: *Blomquist & Correll* 7794 (D). Swain: *Oosting* 34519 (D). Transylvania: *Lovett* 25 (D).

No. PIEDMONT COUNTIES: DAVIE: *Wherry* (P). DURHAM: *Blomquist* 1686 (D). ORANGE: *Correll* 341 (D). STOKES: *Oosting* 1951 (D). SURRY: *Correll & McDowell* 10762 (D). WAKE: *Blomquist* 6297 (D). WARREN: *Scholz* (D). YADKIN: *Correll & McDowell* 10960 (G).

So. PIEDMONT COUNTIES: CATAWBA: *Wherry* (P).

No. COASTAL PLAIN COUNTIES: BEAUFORT: *Correll* 1545 (D). PASQUOTANK: *Correll* 2095 (D). PERQUIMANS: *Glasson* (D). TYRRELL: *Correll* 1806 (D). WASHINGTON: *Correll* 1916 (D).

So. COASTAL PLAIN COUNTIES: HARNETT: *Godfrey* 6154 (D). JONES: *Beaven* 528 (D). WAYNE: *Godfrey* 4270 (D).

OLDEST COLLECTION SEEN: Salem, 1812–21, *L. D. von Schweinitz* (P).

9. **Dryopteris Phegopteris** (L.) C. Chr. (Long Beech Fern). In moist rock crevices under ledges and on cool rocky wood slopes. Newfoundland to Alaska, south to North Carolina and Tennessee, west to Washington; also Greenland, Iceland, Europe, and Asia.

No. MT. COUNTIES: YANCEY: *Knight* (P).

So. MT. COUNTIES: MACON: *Blomquist* 1669 (D).

OLDEST COLLECTION SEEN: MACON: Dry Falls, July 1930, *H. L. Blomquist* 1669 (D).

10. *Dryopteris simulata* Davenp. (Massachusetts or Bog Fern). Although North Carolina is in the range of this species we have seen no collection from the state. It is very probable that this species has been overlooked by collectors in North Carolina because of its similarity to *Dryopteris Thelypteris* var. *pubescens*.

11. **Dryopteris spinulosa** (O. F. Müll.) Watt (Spinulose Shield or Wood Fern). Swamps and low wet woods, seepage and rocky slopes. Labrador and Newfoundland to Idaho, south to North Carolina and Missouri; also Greenland, Europe, and Asia.

So. PIEDMONT COUNTIES: MECKLENBURG: Charlotte, Nov. 8, 1934, *F. W. Gray* (D).

12. **Dryopteris spinulosa** var. **americana** (Fisch.) Fernald (*D. campyloptera* (Kunze) Clarkson) (Spreading Shield Fern, Broad Spinulose Wood Fern). Moist cold woods and ravine slopes, in our range apparently confined to the spruce-balsam association on the higher mountains. Labrador and Newfoundland, west to the Lake Superior region, southward along the higher mountains to North Carolina, Tennessee, and Alabama (?).

No. MT. COUNTIES: ASHE: *Correll* 3971 (D). AVERY: *Wherry* (P). MITCHELL: *Thackston* (D). WATAUGA: *Martin* (NY). YANCEY: *Biltmore Herb.* 6009a (N).

So. Mt. Counties: Buncombe: *Correll* 233 (D). Haywood: *Blomquist* 1665 (D). Jackson: *Blomquist* 1666 (D). Polk: *Peattie* 906 (F). Rutherford: *Barksdale* (NC). Swain: *Harbison* (D). Transylvania: *Holmes* (NC).

Oldest collection seen: Mitchell: Roan Mt., June 1879, *A. Gray, J. H. Redfield, C. S. Sargent & W. M. Canby* (G).

13. **Dryopteris spinulosa** var. **intermedia** (Muhl.) Underw. (*D. intermedia* (Muhl.) A. Gray) (Common Spinulose Wood Fern, American Shield Fern). In rich wood soil on rocky stream banks, low woods or in the spruce-balsam association on the higher mountains where it is often associated with var. *americana*. Newfoundland to Wisconsin, south to South Carolina, Alabama, Missouri, and Texas (?); also Montana and Idaho.

No. Mt. Counties: Ashe: *Blomquist & Anderson* 9986 (D). Avery: *Correll* 3945 (D). Burke: *Rowe & Humphreys* 117 (D). Caldwell (or Watauga): *Atkinson* 12867 (C). Mitchell: *Mohr* (N). Watauga: *Leeds* 402 (P). Yancey: *Biltmore Herb.* 1448a (N).

So. Mt. Counties: Buncombe: *Correll* 247 (D). Clay: *Wherry* (P). Haywood: *Blomquist* 7026 (D). Jackson: *Lovett* 40 (D). Macon: *Blomquist* 1675 (D). McDowell: *Barksdale* (NC). Swain: *Harbison* (D). Transylvania: *Oosting* 34697 (D).

No. Piedmont Counties: Durham: *Blomquist* 1673 (D). Surry: *Lehman* (G).

Oldest collection seen: "Journey to North Carolina," June 18, 1879, *A. Gray, J. H. Redfield, C. S. Sargent & W. M. Canby* (MBG).

14. **Dryopteris Thelypteris** (L.) A. Gray var. **Haleana** (Fern.) Broun (Southern Marsh Fern). This variety is distinguished from var. *pubescens* by usually having its numerous and closely set segments linear-oblong. The midrib beneath is often provided with broad brown or tawny scales at the base of the segments. It is very possible that this segregate should be considered only as a form of var. *pubescens*. In low wet meadows and open swamps. Florida to Louisiana and Texas, north to Pennsylvania.

So. Piedmont Counties: Mecklenburg: *ex herb. Schallert* (D).

14a. **Dryopteris Thelypteris** var. **pubescens** (Lawson) A. R. Prince (Northern Marsh Fern). Swamps, bogs, marshes, wet thickets, and along drainage ditches. Newfoundland to Manitoba, south to Georgia, Florida, and Oklahoma; also northeastern Asia.

No. Mt. Counties: Alleghany: *Correll* 4058 (D). Ashe: *Correll* 4013 (D). Madison: *Wherry* (P).

SO. MT. COUNTIES: HAYWOOD: *Blomquist* 1696 (D). HENDERSON: *Blomquist & Correll* 7813 (D). JACKSON: *Blomquist* 1692 (D). MACON: *Blomquist* 1693 (D).

NO. PIEDMONT COUNTIES: DAVIDSON: *Totten* (NC). DURHAM: *Blomquist* 7388 (D). FORSYTH: *Chitty* (D). GUILFORD: *Mitchell* (D). ORANGE: *Holmes* (NC). WAKE: *Oosting* 35532 (D).

NO. COASTAL PLAIN COUNTIES: BEAUFORT: *Blomquist* (D). CURRITUCK: *Correll* 2178 (D). NASH: *Blomquist* 7700 (D). PERQUIMANS: *Blomquist* 1691 (D). WASHINGTON: *Wiegand & Manning* 25 (C).

SO. COASTAL PLAIN COUNTIES: BRUNSWICK: *Leeds* 529 (P). CARTERET: *Gray* (D). NEW HANOVER: *Blomquist* 1694 (D).

OLDEST COLLECTION SEEN: Salem, 1812–21, *L. D. von Schweinitz* (P).

11. LORINSERIA Presl. Chain-ferns

1. **Lorinseria areolata** (L.) Presl (Dwarf or Narrow-leaved Chain Fern). In open swampy woods and thickets, seepage slopes and bogs. Florida to Texas, Arkansas and Missouri, north to Nova Scotia and Michigan.

SO. MT. COUNTIES: HENDERSON: *Singeltary* (D). MACON: *Coker, Harbison, et al.* (D). POLK: *Peattie* 1196 (NC).

NO. PIEDMONT COUNTIES: BURKE: *Viele* 10 (D). DAVIE: *Wherry* (P). DURHAM: *Blomquist* 1714 (D). FORSYTH: *ex herb. Schallert* (D). GUILFORD: *Mitchell* (D). JOHNSTON: *Correll & Blomquist* 4767 (D). RANDOLPH: *Correll* 733A (D). STOKES: *Foust* (NC). WAKE: *Stites* (D).

SO. PIEDMONT COUNTIES: CATAWBA: *Wherry* (P). GASTON: *Wherry* (P). LINCOLN: *Anderson* (D).

NO. COASTAL PLAIN COUNTIES: BEAUFORT: *Blomquist* 7955 (D). DARE: *Leeds* 525 (P). FRANKLIN: *Blomquist* 6600 (D). GATES: *Godfrey* 5205 (D). HALIFAX: *Wherry* (P). HERTFORD: *Leeds* 3196 (P). HYDE: *Oosting* 41 (D). MARTIN: *Leeds* 526 (P). NASH: *Blomquist* 7578 (D). PASQUOTANK: *Godfrey* 5333 (G). PERQUIMANS: *Glasson* (D). PITT: *Blomquist* 7723 (D). TYRRELL: *Correll* 1804 (D). WASHINGTON: *Godfrey* 4292 (G). WILSON: *Oosting* 35589 (D).

SO. COASTAL PLAIN COUNTIES: BLADEN: *Oosting & Blomquist* 33651 (D). CARTERET: *Gray* (D). COLUMBUS: *Blomquist* 1711 (D). CRAVEN: *Brown* 30 (N). DUPLIN: "Kenansville," *J. H.* (NC). HARNETT: *Blomquist* 1713 (D). HOKE: *Leeds* 682 (P). JONES: *Beaven* 529 (D). LENOIR: *Reed* (D). MOORE: *Oosting* 34772 (D). NEW HANOVER: *Godfrey* 6363 (G). ONSLOW: *Randolph* 935 (G). PAMLICO: *Godfrey*

& White 6792 (D). RICHMOND: *Correll* 7143 (D). ROBESON: *Correll & Blomquist* 7390 (D). SAMPSON: *Leeds* 3195 (P). SCOTLAND: *Smith* (D). WAYNE: *Blomquist & Correll* 4803 (D).

OLDEST COLLECTION SEEN: Salem, 1812–21, *L. D. von Schweinitz* (P).

12. ONOCLEA L. Sensitive Ferns

1. **Onoclea sensibilis** L. (Sensitive Fern). Floodplain woods and thickets along streams, springy slopes, swamps and meadows. Newfoundland to Saskatchewan, south to Florida and Texas; also Asia.

NO. MT. COUNTIES: MADISON: *Rowe* 6 (D).

SO. MT. COUNTIES: BUNCOMBE: *Biltmore Herb.* 683b (G). CHEROKEE: *Oosting* 34617 (D). HAYWOOD: *Blomquist* 1736 (D). JACKSON: *Blomquist* 1740 (D). POLK: *Peattie* 1049 (NC). TRANSYLVANIA: *Oosting* (D).

NO. PIEDMONT COUNTIES: CASWELL: *Correll & McDowell* 10650 (D). CHATHAM: *Correll* 707 (D). DURHAM: *Blomquist* 1739 (D). FORSYTH: *Correll* 251 (D). GRANVILLE: *Blomquist & Correll* 7658 (D). GUILFORD: *Mitchell* (D). JOHNSTON: *Blomquist* 6281 (D). ORANGE: *Correll* 4906 (D). SURRY: *Correll & McDowell* 10763 (D).

NO. COASTAL PLAIN COUNTIES: FRANKLIN: *Blomquist* 8181 (D). PITT: *Blomquist* 7724 (D).

SO. COASTAL PLAIN COUNTIES: BRUNSWICK: *Stites* (D).

OLDEST COLLECTION SEEN: Salem, 1812–21, *L. D. von Schweinitz* (P).

1a. **Onoclea sensibilis** forma **obtusilobata** (Schkuhr) Gilbert. Occurring throughout the range, with the sterile frond approaching the fertile ones in form.

NO. PIEDMONT COUNTIES: ORANGE: *Holland & Matthews* (NC).

13. PELLAEA Link. Cliff-brakes

1. **Pellaea atropurpurea** (L.) Link (Purple Cliff Brake). In crevices of rocky cliffs and ledges of limestone, occasionally on masonry where it occurs on mortar. Florida to Louisiana, Texas and Arizona, north to Vermont, Michigan, and South Dakota; also Mexico.

NO. MT. COUNTIES: MADISON: *Wherry & Anderson* (D). MITCHELL: *Ashe* (NY).

SO. MT. COUNTIES: BUNCOMBE: *Correll* 247A (D). MCDOWELL: *Oosting* 35379 (D). RUTHERFORD: *Hammitt* (D). SWAIN: *Oosting* 35270 (D). TRANSYLVANIA: *Oosting* 36108 (D).

NO. PIEDMONT COUNTIES: FORSYTH: *Schallert* (D). MCDOWELL: *Knight* (D). YADKIN: *Oosting* 2032 (D).

OLDEST COLLECTION SEEN: Salem, 1812–21, *L. D. von Schweinitz* (P).

14. POLYPODIUM L. Polypody

1. **Polypodium polypodioides** (L.) Watt (Resurrection Fern, Gray Polypody). On tree trunks and limbs on the Coastal Plain, on trees and rocks in the Piedmont Region and on rocks and logs in the Mountain Region. Florida, north to Maryland and Delaware, west to Texas and Iowa; also throughout tropical America south to Argentina, also South Africa.

NO. MT. COUNTIES: CALDWELL: *Small & Heller* 209 (F). MADISON: *Oosting* 34309 (D). WILKES: *Correll & McDowell* 10951 (D).

SO. MT. COUNTIES: BUNCOMBE: *Teague* (D). CLAY: *Oosting* 34583 (D). HAYWOOD: *Blomquist* 1764 (D). MACON: *ex herb. Dunham* (F). MCDOWELL: *Rowe & Humphreys* 107 (D). POLK: *Correll* 3230 (D). RUTHERFORD: *Blomquist & Correll* 7800 (D). SWAIN: *Beardslee & Kofoid* (O).

NO. PIEDMONT COUNTIES: BURKE: *Viele* 20 (D). DURHAM: *Blomquist* 1765 (D). GRANVILLE: *Blomquist & Correll* 7660 (D). ORANGE: *Oosting* 33249 (D). RANDOLPH: *Correll* 741 (D). ROCKINGHAM: *Correll & McDowell* 10705 (D). ROWAN: *Heller* 209 (NY). VANCE(?): *Faxon* (G). WAKE: *Godfrey* 3986 (G).

SO. PIEDMONT COUNTIES: CABARRUS: *Blomquist* 1763 (D). LEE: *Blomquist* 1761 (D). MONTGOMERY: *Oosting* 1855 (D). STANLY: *Oosting* 1851 (D).

NO. COASTAL PLAIN COUNTIES: BERTIE: *Correll* 1994 (D). CAMDEN: *Wherry* (P). CHOWAN: *Davis* (MBG). DARE: *Canby* (Mich). FRANKLIN: *Blomquist* 6603 (D). HALIFAX: *Bartram* (P). HERTFORD: *Correll* 2299 (D). PASQUOTANK: *Chickering* (F). WASHINGTON: *Wiegand & Manning* 12 (G).

SO. COASTAL PLAIN COUNTIES: BLADEN: *Blomquist* 7143 (D). BRUNSWICK: *Blomquist* 1762 (D). CARTERET: *Gray* (D). COLUMBUS: *Godfrey* 4161 (G). CRAVEN: *Godfrey* 3718 (G). HARNETT: *Blomquist* 7141 (D). JONES: *Beaven* 522 (D). NEW HANOVER: *Williamson* (P). SAMPSON: *Correll* 1282 (D). WAYNE: *Blomquist & Correll* 4801 (D).

OLDEST COLLECTION SEEN: MADISON: Warm Springs, on rocks, Aug. 24, 1876, *J. H. Redfield* (P).

2. **Polypodium virginianum** L. (Virginia or Common Polypody). On large boulders, rock cliffs and ledges, rotten logs or base of tree trunks, and occasionally on wooded banks, usually in the vicinity of streams. Newfoundland to Alberta, south to Georgia, Alabama, Arkansas, and Texas (?).

NO. MT. COUNTIES: ALLEGHANY: *Correll & McDowell* 10823 (D).

ASHE: *Correll* 3974 (D). AVERY: *Correll & McDowell* 10898 (D). BURKE: *Correll* 3911 (D). CALDWELL (or Watauga): *Durand* 12877 (C). MADISON: *Trentham* (D). MITCHELL: *Oosting* 3613 (D). WATAUGA: *Small & Heller* 449 (NY). YANCEY: *Wherry* (P).

So. Mt. Counties: BUNCOMBE: *Correll* 14 (D). GRAHAM: *Correll* 3679 (D). HAYWOOD: *Blomquist* 1768 (D). JACKSON: *Blomquist* 1766 (D). MACON: *Blomquist* 6728 (D). McDOWELL: *Correll & Blomquist* 4690 (D). POLK: *Townsend* 1 (C). RUTHERFORD: *Blomquist & Correll* 7797 (D). SWAIN: *Harbison* (D). TRANSYLVANIA: *Oosting* 34694 (D).

No. Piedmont Counties: DURHAM: *Blomquist* 1767 (D). GRANVILLE: *Blomquist & Correll* 7659 (D). ORANGE: *Blomquist* 1769 (D). ROCKINGHAM: *Correll & McDowell* 10701 (D). STOKES: *Oosting* 1959 (D). SURRY: *Correll* 4932 (D). VANCE(?): *Faxon* (G). WILKES: *Blomquist & Anderson* 10039 (D). YADKIN: *Correll & McDowell* 10962 (G).

So. Piedmont Counties: GASTON: *Oosting* 1664 (D).

Oldest collection seen: Salem, 1812–21, *L. D. von Schweinitz* (P).

2a. **Polypodium virginianum** forma **cambricoides** F. W. Gray. A form with deeply pinnatifid pinnae which is not known to fruit. New Hampshire and New York to western North Carolina.

So. Mt. Counties: BUNCOMBE: near summit of Bald Knob Mt., on small rock ledge in woods, 1933, *Correll* 13 (D).

2b. *Polypodium virginianum* forma *deltoideum* (Gilbert) Fernald. Broun (Index to N. Amer. Ferns, p. 143, 1938) gives "Quebec to North Carolina" as the distribution for this form. However, no collections referable to it were seen from North Carolina. It is distinguished by its rather broad blade which is often triangular in outline. The lowermost segments have an elongate lobe on one or both sides at the base.

15. POLYSTICHUM Roth. Christmas Ferns

1. **Polystichum acrostichoides** (Michx.) Schott (Christmas Fern, Santa Claus Fern). Rocky well-drained wooded slopes, thickets and on small knolls in swamps. Nova Scotia to Wisconsin, south to Florida and Texas; also Mexico.

No. Mt. Counties: ALLEGHANY: *Correll & McDowell* 10831 (D). ASHE: *Blomquist & Anderson* 9970 (D). AVERY: *Correll & McDowell* 10916 (D). MADISON: *Pethick* 99 (D). MITCHELL: *Cannon* 51 (N). WATAUGA: *Martin* (NY). WILKES: *Correll & McDowell* 10935 (D). YANCEY: *Wherry* (P).

So. Mt. Counties: Buncombe: *Teague* (D). Cherokee: *Oosting* 34618 (D). Clay: *Oosting* 34576 (D). Haywood: *Blomquist* 1778 (D). Henderson: *Blomquist* 1774 (D). Jackson: *Lovett* 6 (D). Macon: *Coker & Holland* (D). McDowell: *Oosting* 35362 (D). Polk: *Peattie* 1393 (NC). Rutherford: *Oosting* 34719 (D). Swain: *Pethick* 75 (D). Transylvania: *Wherry* (P).

No. Piedmont Counties: Burke: *Viele* 1 (D). Caldwell: *Blomquist* 7909 (D). Caswell: *Correll & McDowell* 10649 (D). Chatham: *Correll* 716 (D). Davie: *Wherry* (P). Durham: *Blomquist* 6741 (D). Forsyth: *Correll* 2630 (D). Granville: *Correll* 487 (D). Guilford: *Schallert* 776 (D). Orange: *Blomquist* 1770 (D). Person: *Blomquist* (D). Rockingham: *Correll & McDowell* 10703 (D). Rowan: *Beck* 5 (D). Stokes: *Correll & McDowell* 10724 (D). Surry: *Blomquist* 6621 (D). Vance: *Wherry* (P). Wake: *Blomquist* 1775 (D). Yadkin: *Correll & McDowell* 10963 (D).

So. Piedmont Counties: Catawba: *Wherry* (P). Gaston: *Blomquist, Correll & Garren* 7773 (D). Lee: *Oosting* 3434 (D). Montgomery: *Correll* 7032 (D).

No. Coastal Plain Counties: Beaufort: *Correll* 1549 (D). Hertford: *Leeds* 3079 (P). Tyrrell: *Correll* 1808 (D).

So. Coastal Plain Counties: Brunswick: *Leeds* 368 (P). Moore: (1929)—(NC). Onslow: *Godfrey* 4493 (G). Pender: *Godfrey* 6590 (G).

Oldest collection seen: Salem, 1812–21, *L. D. von Schweinitz* (P).

1a. **Polystichum acrostichoides** forma **incisum** (A. Gray) Gilbert. Plants found throughout the range having coarsely and deeply toothed pinnae, with the lower ones often fertile at the tip.

No. Mt. Counties: Wilkes: *Schallert* (D).

So. Mt. Counties: Buncombe: *Correll* 235 (NC). Polk: *Millspaugh* 4104 (F). Rutherford: *Leeds* 552 (P).

No. Piedmont Counties: Burke: *Viele* 2 (D). Durham: *Blomquist* 1771 (D).

No. Coastal Plain Counties: Halifax: *Williamson* (P).

16. Pteretis Raf. Ostrich Ferns

1. **Pteretis nodulosa** (Michx.) Nieuwl. (Ostrich Fern). Boggy seepage slopes, swamps and wooded alluvial flats. Newfoundland to Alaska, south to North Carolina and Missouri. First time found in North Carolina!

No. Mt. Counties: Watauga: Cultivated by Mrs. Craggs in Boone (collected by her about 1 mile southeast of Boone), *Correll & McDowell* 10896 (D).

17. Pteridium Scop. Bracken Ferns

1. **Pteridium aquilinum** (L.) Kuhn (Bracken). According to R. M. Tryon, Jr., who has just completed a monograph of this genus, this species is represented in North Carolina by var. *latiusculum* (Desv.) Underw. and var. *pseudocaudatum* Clute.

Variety *latiusculum* is found throughout the state but is more abundant in the mountains since it is primarily a northeastern variety. It ranges from Newfoundland to Wyoming, south to North Carolina, Alabama, and Arizona. It is characterized by being ternate with the lowest pinnae abruptly larger than those immediately above. The terminal pinnules are not long-produced and entire as in var. *pseudocaudatum*, being only about 4 times as long as broad, and the plants are sparsely pubescent, especially on the margins of the lobes and along the midnerve. The growing tip of the rhizome is usually naked or with a few whitish hairs.

Variety *pseudocaudatum*, the typically southern and Coastal Plain plant, is the most common of the two varieties in North Carolina. It ranges from Florida to Texas, northward to Massachusetts and Iowa. The writers have examined specimens of this variety from practically every county in the Piedmont and Coastal Plain regions in the state, as well as from a number of counties in the mountains. It resembles var. *latiusculum* but differs from it in that the terminal pinnules are long-produced and entire, being from 7–15 (averaging 9) times as long as broad, and the plants are nearly or quite glabrous. The growing tip of the rhizome usually has a tuft of dark hairs.

Oldest collection seen for Pteridium: Salem, 1812–21, *L. D. von Schweinitz* (P).

18. Pteris L. Brake Ferns

1. **Pteris multifida** Poir. (Huguenot Fern). This fern is commonly grown as a house plant and in greenhouses. It occurs as an escape from Florida to North Carolina and Louisiana where it is found mainly on masonry. In Louisiana, it has been collected on wooded banks along streams.

So. Coastal Plain Counties: New Hanover: Wilmington, Sept. 1932, *Gertrude Grimsley* (D).

19. WOODSIA R. Br. Woodsias

1. **Woodsia ilvensis** (L.) R. Br. (Rusty Woodsia). On dry ledges, cliffs and rocky slopes. Baffin Bay and Labrador to Alaska, south to the mountains of northwestern North Carolina, west to Iowa and British Columbia; also Greenland, Iceland, Europe, and Asia.

No. MT. COUNTIES: ASHE: *Wherry* (D).

OLDEST COLLECTION SEEN: ASHE: 1841, *A. Gray & J. Carey* (G).

2. **Woodsia obtusa** (Spreng.) Torr. (Blunt-lobed Woodsia). On exposed rocks and in crevices and soil under open rock ledges, well-drained shady soil and in mountain pasturelands. Nova Scotia to Minnesota, south to Florida, west to Texas and Arizona; also Alaska to British Columbia.

No. MT. COUNTIES: ALLEGHANY: *Correll & McDowell* 10820 (D). ASHE: *Blomquist & Anderson* 9969 (D). AVERY: *Correll & McDowell* 10907 (D). MADISON: *Rogers* 49 (D).

SO. MT. COUNTIES: BUNCOMBE: *Correll* 61 (D). HAYWOOD: *Blomquist* 2896 (D). JACKSON: *Blomquist* 2876 (D). MACON: *Blomquist* 6727 (D). MCDOWELL: *Oosting* 35383 (D). POLK: *Townsend* 13 (C). RUTHERFORD: *Blomquist & Correll* 7796 (D). SWAIN: *Oosting* 35269 (D). TRANSYLVANIA: *House* 4271 (N).

NO. PIEDMONT COUNTIES: BURKE: *Wherry* (P). DURHAM: *Blomquist* 2893 (D). FORSYTH: *Denke* (?) (D). GRANVILLE: *Blomquist & Correll* 7661 (D). ORANGE: *Blomquist & Oosting* 3372 (D). STOKES: *Blomquist* 9278 (D). WAKE: *Oosting* 56 (D). WILKES: *Blomquist & Anderson* 10025 (D).

SO. PIEDMONT COUNTIES: CATAWBA: "Hickory"—(NC). MONTGOMERY: *Oosting* 1890 (D). STANLY: *Oosting* 1899 (D).

NO. COASTAL PLAIN COUNTIES: FRANKLIN: *Oosting* 35621 (D).

OLDEST COLLECTION SEEN: Salem, 1812–21, *L. D. von Schweinitz* (P).

3. **Woodsia scopulina** D. C. Eaton (Rocky Mountain Woodsia). In crevices of cliffs and ledges and on rocky open slopes. Quebec and Ontario, south to North Carolina, Tennessee, and Oklahoma, through the Great Lake region to Alaska and California.

SO. MT. COUNTIES: BUNCOMBE: *Ferriss* (N). POLK: *Wherry* (D).

OLDEST COLLECTION SEEN: POLK: White Oaks, Aug. 14, 1897, *E. C. Townsend* 13a (C).

FAMILY 3. SCHIZAEACEAE. Curly-grass Family

1. LYGODIUM Sw. Climbing Ferns

1. **Lygodium japonicum** (Thunb.) Sw. (Japanese Climbing Fern). Escaped from cultivation and naturalized in thickets, low moist woods, and along ditches. Florida to Louisiana, north to North Carolina; also Asia and the Australian tropics.

So. COASTAL PLAIN COUNTIES: CUMBERLAND: *Totten* (NC).

OLDEST COLLECTION SEEN: CUMBERLAND: near Fayetteville, Aug. 1933, *H. A. Rankin* (NY).

2. **Lygodium palmatum** (Bernh.) Sw. (Climbing Fern). Climbing on thickets along streams and in floodplain areas, seepage banks, usually associated with sphagnum in very acid soil. Florida (probably as an escape from cultivation) and Georgia to Texas, north to New Hampshire and Ohio.

So. MT. COUNTIES: HENDERSON: *Holmes* (NC). TRANSYLVANIA: *Thackston* (D).

No. PIEDMONT COUNTIES: IREDELL: *Hyams* (Minn). STOKES: *Yocum* 313 (D). SURRY: *Ashe* (NY).

So. PIEDMONT COUNTIES: MOORE: "High Falls"—(O).

So. COASTAL PLAIN COUNTIES: CUMBERLAND: *Vardell* (D). DUPLIN: *McVaugh* 2457 (Pa.). MOORE: *Wicker* (NC). SAMPSON: *Evans & Anderson* 6159 (D).

OLDEST COLLECTION SEEN: Along mountain stream, Blue Ridge, Sept. 1, 1876, *George Engelmann* (MBG).

FAMILY 4. OSMUNDACEAE. Cinnamon-fern Family

1. OSMUNDA L. Cinnamon Ferns

1. **Osmunda cinnamomea** L. (Cinnamon Fern). Springy slopes, moist depressions in woods, swamps and marshes, pocosins and low places in savannahs. Newfoundland to Minnesota, south to Florida and New Mexico.

No. MT. COUNTIES: ALLEGHANY: *Correll & McDowell* 10793 (D). BURKE: *Leeds* 805 (P). MADISON: *Rowe* 8 (D). WATAUGA: *Martin* (NY).

So. MT. COUNTIES: BUNCOMBE: *Correll* 234 (D). CHEROKEE: *Oosting* 34621 (D). HAYWOOD: *Blomquist* 1746 (D). HENDERSON: *Blomquist & Correll* 7814 (D). JACKSON: *Blomquist* 6731 (D). MACON: *Pethick* 53 (D). MCDOWELL: *Blomquist & Correll* 4696 (D). POLK: *Millspaugh* 4156 (F). RUTHERFORD: *Blomquist & Correll*

7785 (D). SWAIN: *Pethick* 70 (D). TRANSYLVANIA: *Oosting* 34701 (D).

No. PIEDMONT COUNTIES: ALAMANCE: *Blomquist* 1747 (D). BURKE: *Viele* 14 (D). DAVIE: *Wherry* (P). DURHAM: *Blomquist* 1799 (D). FORSYTH: *Schallert* (G). GRANVILLE: *Blomquist & Correll* 7665 (D). GUILFORD: *Mitchell* (D). ORANGE: *Correll* 319 (D). ROCKINGHAM: *Oosting* 33410 (D). STOKES: *Oosting* 1937 (D). SURRY: *Oosting* 3522 (D). WAKE: *Blomquist* 1745 (D). YADKIN: *Matthews & Ward* (NC).

No. COASTAL PLAIN COUNTIES: DARE: *Leeds* 3637 (P). FRANKLIN: *Blomquist* 6599 (D). JOHNSTON: *Blomquist & Correll* 4782 (D). NASH: *Blomquist* 7564 (D). PERQUIMANS: *Glasson* (D). PITT: *Schallert* 1006 (D). WASHINGTON: *Godfrey* 3908 (G). WILSON: *Oosting* 35586 (D).

So. COASTAL PLAIN COUNTIES: BLADEN: *Blomquist* 7025 (D). BRUNSWICK: *Blomquist* 1743 (D). CUMBERLAND: *Godfrey* 3383 (D). HOKE: *Leeds* 672 (P). JONES: *Beaven* 470 (D). MOORE: *Holland & Matthews* (D). ROBESON: *Vardell* (NC). SAMPSON: *Correll* 385 (D). WAYNE: *Blomquist* 1744 (D).

OLDEST COLLECTION SEEN: Salem, 1812–21, *L. D. von Schweinitz* (P).

1a. **Osmunda cinnamomea** forma **frondosa** (Torr. & A. Gray) Britton. Throughout the range. A condition with sterile and fertile tissue on the same frond.

So. MT. COUNTIES: HAYWOOD: *Blomquist* 9581 (D).

So. PIEDMONT COUNTIES: STANLY: *Lyerly* (NC).

2. **Osmunda Claytoniana** L. (Interrupted Fern). Moist rocky wooded slopes, thickets, meadows and edges of swamps. Newfoundland to Manitoba, south to Georgia and Arkansas; also Greenland.

No. MT. COUNTIES: ALLEGHANY: *Correll & McDowell* 10833 (D). ASHE: *Correll & McDowell* 10837 (D). AVERY: *Wherry* (P). BURKE: *Rowe & Humphreys* 118 (D). MADISON: *Rowe* 7 (D). MITCHELL: *Cannon* 189 (N). WATAUGA: *Vardell* (NC).

So. MT. COUNTIES: BUNCOMBE: *Correll* 26 (D). HAYWOOD: *Blomquist* 1750 (D). JACKSON: *Blomquist* 1751 (D). MACON: *Blomquist* 6729 (D). POLK: *Townsend* (C). SWAIN: *Barksdale* (NC). TRANSYLVANIA: *Rowe & Humphreys* 125 (D).

No. PIEDMONT COUNTIES: BURKE: *Viele* 15 (D). PERSON: *Wherry* (P).

OLDEST COLLECTION SEEN: Salem, 1812–21, *L. D. von Schweinitz* (P).

3. **Osmunda regalis** L. var. **spectabilis** (Willd.) A. Gray (Royal Fern). In swamps, marshes, moist woods and springy slopes, moist

depressions in savannahs and pocosins. Newfoundland to Saskatchewan, south to Florida and Texas; also the West Indies, Mexico, and Central and northern South America.

No. Mt. Counties: Alleghany: *Correll & McDowell* 10798 (D). Madison: *Trentham* (D). Mitchell: *Ashe* (NC). Yancey: *Wherry* (P).

So. Mt. Counties: Buncombe: *Pethick* 68 (D). Cherokee: *Correll* 3591 (D). Clay: *Wherry* (P). Graham: *Correll* 3689 (D). Haywood: *Blomquist* 1752 (D). Henderson: *Blomquist, Correll & Garren* 7807 (D). Jackson: *Blomquist* 1753 (D). Macon: *Holland, et al.* (D). McDowell: *Blomquist & Correll* 4695 (D). Polk: *Peattie* 728 (NC). Transylvania: *Rowe & Humphreys* 130 (D).

No. Piedmont Counties: Burke: *Viele* 13 (D). Caswell: *Correll & McDowell* 10673 (D). Davie: *Wherry* (P). Durham: *Avery* (D). Guilford: *Schallert* 777 (D). Orange: *Correll* 318 (D). Rockingham: *Oosting* 33409 (D). Wake: *Blomquist* 6298 (D).

So. Piedmont Counties: Anson: *Correll* 1041 (D). Montgomery: *Correll* 832 (D). Moore: *Wherry* (P). Rowan: *Heller* 10287 (B).

No. Coastal Plain Counties: Beaufort: *Blomquist* 6722 (D). Chowan: *Correll* 2040 (D). Currituck: *Correll* 2171 (D). Dare: *Correll* 1727 (D). Hyde: *Correll* 1743 (D). Johnston: *Correll & Blomquist* 4780 (D). Nash: *Oosting* 35561 (D). Northampton: *Leeds* 669 (P). Pasquotank: *Oosting* 35506 (D). Perquimans: *Glasson* (D). Pitt: *Blomquist* 7737 (D). Tyrrell: *Correll* 1883 (D). Washington: *Correll* 1911 (D).

So. Coastal Plain Counties: Bladen: *Blomquist* 1757 (D). Brunswick: *Matthews* (D). Columbus: *Blomquist* 1756 (D). Craven: *Godfrey* 3723 (G). Hoke: *Leeds* 668 (P). New Hanover: *Blomquist* 1755 (D). Pamlico: *Correll* 1503 (D). Pender: *Correll* 424 (D). Richmond: *Correll* 1107 (D). Robeson: *Correll* 1220 (D). Sampson: *Correll* 1283 (D). Wayne: *Correll & Blomquist* 4804 (D).

Oldest collection seen: Salem, 1812–21, *L. D. von Schweinitz* (P)

ORDER II. OPHIOGLOSSALES

Family 1. Ophioglossaceae. Adder's-tongue Family

1. Botrychium Sw. Grape Ferns

1. **Botrychium alabamense** Maxon (Alabama Grape Fern). In moist low woods along streams and in damp pinelands. Florida, Georgia and Alabama to North Carolina.

So. Mt. Counties: Buncombe: *Hoffman* (D).

No. Piedmont Counties: Davie: *Wherry* (P).

So. Piedmont Counties: Mecklenburg: *Gray* (D). Polk: *Townsend* 15 (C).

Oldest collection seen: Polk: Columbus, Nov. 1897, *E. C. Townsend* 15 (C).

2. **Botrychium dissectum** Spreng. (Cut-leaved Grape Fern). Floodplain woods, lowland thickets and in open upland woods. Southern Nova Scotia, New Brunswick, and Quebec to southern Minnesota, south to Georgia, Florida (?), and eastern Missouri.

So. Mt. Counties: Haywood: *Holmes* (NC).

No. Piedmont Counties: Burke: *Viele* 5 (D). Durham: *Love, Smith & Edwards* (D). Forsyth: *Wherry* (P). Guilford: *Mitchell* (D). Orange: *Correll* 4910 (D). Wake: *Hyams* (NC).

So. Piedmont Counties: Mecklenburg: *Gray* (D). Montgomery: *Correll* 7038 (D).

Oldest collection seen: Haywood: Aug. 20, 1903, *J. S. Holmes* (NC).

3. **Botrychium obliquum** Muhl. (*B. dissectum* var. *obliquum* (Muhl.) Clute; *B. dissectum* var. *tenuifolium* (Underw.) Farwell) (Common Grape Fern). Floodplain woods, thickets, and on the edge of meadows and pastures. Southern Nova Scotia and New Brunswick, west to Wisconsin and Iowa, south to Florida and Louisiana; also Jamaica.

Botrychium obliquum is characterized by having a membranous or somewhat coriaceous blade which is variously divided into segments whose margins are nearly entire, crenate or prominently serrate but never deeply and finely lacerate or divided.

This species, which is widespread and rather common throughout the southeastern states, has not only been treated by some authors as a variety of *B. dissectum* but has also been divided by others into several other varietal segregates of *B. dissectum;* namely *B. dissectum* var. *tenuifolium* and *B. dissectum* var. *oneidense* (Gilbert) Farwell. At most, these should be considered only as leaf forms of *B. obliquum*. Furthermore, if leaf forms are to be recognized in this species, why stop with so few? Various specimens of this species have been seen from Tennessee, Mississippi, Alabama, and Louisiana which deserve a name if var. *tenuifolium* is worthy of taxonomic standing.

Botrychium dissectum has been found sparingly in the southern mountains and Piedmont Plateau of North Carolina, while *B. obliquum*

occurs rather abundantly in all sections of the state. It is true that intermediate forms may be found where the two species occur in proximity. However, it is very possible that this is the result of interbreeding of dissimilar individuals which is of rather common occurrence in ferns. We do not recall having seen any intermediate forms south of North Carolina and Tennessee.

In this paper, the authors consider *B. obliquum* to be a polymorphic species which is susceptible of being divided into innumerable segregates.

No. Mt. Counties: Alleghany: *Wherry* (P). Ashe: *Correll* 4045 (D). Avery: *Wherry* (P). Madison: *Oosting* 34484 (D). Mitchell: *Cannon* 219 (NY). Watauga: *Randolph* 1157 (G).

So. Mt. Counties: Buncombe: *Correll* 3836 (D). Graham: *Ferriss* (MBG). Haywood: *Pethick* 93 (D). Henderson: *Correll* 7863 (D). Macon: *Correll* 7869 (D). McDowell: *Correll & Blomquist* 4681 (D). Rutherford: *Wherry* (P). Swain: *Correll* 3742 (D). Transylvania: *Holmes* (NC).

No. Piedmont Counties: Burke: *Viele* 9 (D). Caldwell: *Blomquist* 7710 (D). Davie: *Wherry* (P). Durham: *Avery* (D). Forsyth: *Correll* 4082 (D). Granville: *Stites* (D). Guilford: *Schallert* 1007 (D). Johnston: *Blomquist* 6270 (D). Orange: *Blomquist* 1641 (D). Surry: *Wherry* (P). Wake: *Hyams* (NC). Yadkin: *Matthews & Ward* (NC).

So. Piedmont Counties: Lincoln: *Anderson* (D). Mecklenburg: *Gray* (D). Montgomery: *Correll* 7037 (D).

No. Coastal Plain Counties: Franklin: *Blomquist* 8178 (D). Nash *Leeds* 3591 (P).

So. Coastal Plain Counties: Brunswick: *Correll & Blomquist* 4887 (D). Moore: *Correll* 6989 (D). Pender: *Godfrey* 6522 (G).

Oldest collection seen: Salem, 1812–21, *L. D. von Schweinitz* (P).

4. **Botrychium virginianum** (L.) Sw. (Rattlesnake Fern). In moist well-drained woodlands and thickets. Prince Edward Island and New Brunswick to southern British Columbia, south to central Florida, Louisiana, and Texas, west to California and Mexico (?); also eastern Asia.

No. Mt. Counties: Alleghany: *Correll & McDowell* 10794 (D). Ashe: *Blomquist & Anderson* 9957 (D). Avery: *Correll* 3926 (D). Madison: *Trentham* (D). Watauga: *Small & Heller* 388 (P). Yancey: *Correll* 3881 (D).

So. Mt. Counties: Buncombe: *Teague* (D). Cherokee: *Correll* 3590 (D). Haywood: *Oosting* 34162 (D). Henderson: *Correll* 3313

(D). JACKSON: *Blomquist* 1642 (D). MACON: *Coker* (NC). MCDOWELL: *Oosting* 35376 (D). POLK: *Correll* 3221 (D). RUTHERFORD: *Blomquist & Correll* 7789 (D). SWAIN: *Correll* 3738 (D). TRANSYLVANIA: *Correll* 3395 (D).

No. PIEDMONT COUNTIES: BURKE: *Viele* 8 (D). CASWELL: *Correll & McDowell* 10675 (D). CHATHAM: *Correll* 705 (D). DAVIDSON: *Correll* 769 (D). DAVIE: *Correll* 2753 (D). DURHAM: *Blomquist* 1644 (D). FORSYTH: *Correll* 4086 (D). GRANVILLE: *Correll* 507 (D). GUILFORD: *Mitchell* (D). ORANGE: *Oosting* 3367 (D). PERSON: *Wherry* (P). RANDOLPH: *Correll* 726 (D). ROCKINGHAM: *Oosting* 33407 (D). STOKES: *Correll & McDowell* 10738 (D). SURRY: *Oosting* 3531 (D). WAKE: *Buell* 1347 (D). WARREN: *Godfrey* 3612 (G). WILKES: *Blomquist & Anderson* 10034 (D). YADKIN: *Oosting* 33492 (D).

So. PIEDMONT COUNTIES: CATAWBA: *Correll* 2830 (D). GASTON: *Correll* 2950 (D). LEE: *Oosting* 3433 (D). LINCOLN: *Correll* 2899 (D). MECKLENBURG: *Correll* 3043 (D). MONTGOMERY: *Correll* 7039 (D).

No. COASTAL PLAIN COUNTIES: FRANKLIN: *Blomquist* 8177 (D). HALIFAX: *Small* (NY).

So. COASTAL PLAIN COUNTIES: CRAVEN: *Leeds* 41 (P). MOORE: "toward Vass"—(NC).

OLDEST COLLECTION SEEN: Salem, 1812–21, *L. D. von Schweinitz* (P).

2. OPHIOGLOSSUM L. Adder's Tongue Ferns

1. *Ophioglossum Engelmanni* Prantl. North Carolina is in the range of this species. However, no collection was seen from the state.

2. **Ophioglossum vulgatum** L. (Common Adder's Tongue). In moist open woods, floodplain woods and low grassy meadows. Prince Edward Island to Alaska, south to Florida, Texas, and Arizona; also Mexico, Iceland, British Isles, Europe, Asia, and Africa.

So. MT. COUNTIES: BUNCOMBE: *Wherry* (P).

No. PIEDMONT COUNTIES: DURHAM: *Blomquist* (D). FORSYTH: *Denke* (D). GUILFORD: *Grimsley* 33 (D). ORANGE: *Correll* 5100 (D).

No. COASTAL PLAIN COUNTIES: BERTIE: *Palmer* 39797 (G). HALIFAX: *Bartram* (P).

So. COASTAL PLAIN COUNTIES: WAYNE: *Grimsley* (D).

OLDEST COLLECTION SEEN: FORSYTH: Winston Salem, 1826, *C. F. Denke* (D).

ORDER III. SALVINIALES

FAMILY 1. SALVINIACEAE. Salvinia Family

1. AZOLLA Lam. Water Ferns

1. **Azolla caroliniana** Willd. (Mosquito or Water Fern). Floating on water in ponds, sluggish streams and ditches, or resting on mud. Florida to Texas, North Carolina, Massachusetts (escaped from cultivation and not persistent), Ohio, Arizona, and Alaska; also the West Indies and Mexico to Patagonia.

No. COASTAL PLAIN COUNTIES: CURRITUCK: *Blomquist & Anderson* (D).

So. COASTAL PLAIN COUNTIES: BRUNSWICK: *Bartram & Long* 1069 (P).

OLDEST COLLECTION SEEN: BRUNSWICK: Vic. of Wilmington, west side of the Cape Fear River, April 14–17, 1911, *E. B. Bartram & Bayard Long* 1069 (P).

ORDER IV. EQUISETALES

FAMILY 1. EQUISETACEAE. Horsetail Family

1. EQUISETUM [Tourn.] L.

1. **Equisetum arvense** L. (Field Horsetail). Open rocky wood slopes, meadows, sandy soil along streams and on roadsides and railroad embankments. Newfoundland to Alaska and California, south to Alabama; also Greenland, Spitzbergen, Europe, Asia, and northern Africa.

No. MT. COUNTIES: ASHE: *Blomquist & Anderson* 10000 (D). AVERY: *Correll & McDowell* 10920 (D). BURKE: *Hoffman* (D). MADISON: *Oosting* 34477 (D).

So. MT. COUNTIES: BUNCOMBE: *Biltmore Herb.* (NY). HAYWOOD: *Blomquist* 1699 (D).

No. PIEDMONT COUNTIES: ROCKINGHAM: *Correll & McDowell* 10698 (D). SURRY: *Schallert* (D).

No. COASTAL PLAIN COUNTIES: CHOWAN: *Blomquist* 1698 (D).

OLDEST COLLECTION SEEN: BUNCOMBE: Reems Creek, 1899, *Biltmore Herb.* (NY).

2. *Equisetum kansanum* forma *elatum* (Engelm.) Broun, Index to N. Amer. Ferns, p. 89. 1938. Broun gives in quotation "North Carolina and Kentucky" for the range of this form. This is evidently based on the following statement under *Equisetum laevigatum* v *elatum* Engelm. by Engelmann (Am. Journ. Sci. and Arts **46**: 87. 1844): "Near Newbern,

North Carolina, (Loomis & Croom in herb. Short). Mr. Curtis informs me that this is probably the only species in that section."

Mr. Curtis very probably had reference to *E. praealtum*. It seems strange that a form of a species whose range is Ohio to British Columbia, Texas, and southern California should be found in eastern North Carolina. However, there is a possibility that Engelmann had in hand a transient ballast plant which has not since been collected from New Bern or elsewhere along the North Carolina coast.

3. **Equisetum praealtum** Raf. (Giant Horsetail or Tall Scouring-rush). Sandy or rocky stream banks in the open or open woods and on alluvial flats. Nova Scotia to Florida and Louisiana, west to Great Slave Lake in the Northwest Territory, British Columbia, and California; also Mexico.

No. Mt. Counties: Madison: *Rowe* 42 (D). McDowell: *Shanor, Ferger and Christenberry* (NC). Yancey: *Holmes* (NC).

So. Mt. Counties: Buncombe: *Oosting* 34465 (D). Haywood: *Blomquist* 1704 (D). Jackson: *Blomquist* 1700 (D).

No. Piedmont Counties: Alamance: *Correll* 8667 (D). Caswell: *Oosting* (D). Durham: *Williams* (D). Orange: *Totten* (NC).

No. Coastal Plain Counties: Chowan: *Blomquist* 1706 (D). Halifax: *Canby* (MBG).

Oldest collection seen: Halifax: Weldon, Oct. 1867, *W. M. Canby* (MBG).

4. **Equisetum scirpoides** Michx. (Sedge-like Horsetail, Dwarf Scouring-rush). Seepage slopes in coniferous woods or in the open and on the edge of meadows, swamps and bogs. Arctic regions, through New England and in isolated areas southward to North Carolina, west to Alaska, Washington, and South Dakota; also Greenland, Spitzbergen, Europe, and Asia.

No. Piedmont Counties: Iredell: Statesville, *M. E. Hyams* (MBG).

ORDER V. LYCOPODIALES

Family 1. Lycopodiaceae. Clubmoss Family

1. Lycopodium [Dill.] L.

1. **Lycopodium adpressum** (Chapm.) Lloyd & Underw. (Southern Clubmoss). In low depressions in savannahs and pinelands, bogs and sphagnous situations. Mostly on the Coastal Plain from Florida to New York and Texas.

So. Mt. Counties: Clay: *Ashe* 1098 (NC).

No. Piedmont Counties: Rowan: *Small* (P).

So. Piedmont Counties: Anson: *Correll* 1038 (D).

No. Coastal Plain Counties: Beaufort: *Correll* 1709 (D). Camden: *Blomquist* 1716 (D). Chowan: *Correll* 2030 (D). Gates: *Correll* 2252A (D). Johnston: *Deans* (NC). Martin: *Correll* 1878 (D). Northampton: *Correll* 2361 (D).

So. Coastal Plain Counties: Bladen: *Blomquist* 10176 (D). Craven: *Correll* 1453A (D). Greene: *Correll* 1335 (D). Hoke: *Correll* 7180 (D). Onslow: *Randolph* 971 (in part) (C). Pamlico: *Correll* 1490 (D). Richmond: *Correll* 1112 (D). Sampson: *Oosting* 3550 (D).

Oldest collection seen: Clay: 1893, *W. W. Ashe* 1098 (NC).

2. **Lycopodium alopecuroides** L. (Foxtail Clubmoss). In low moist pinelands, edge of pocosins and seepage slopes. Mostly on the Coastal Plain from Florida to New York and Louisiana; also South America.

So. Mt. Counties: Henderson: *Biltmore Herb.* 595a (G).

No. Piedmont Counties: Guilford: *Hall* (D). Wake: *Godfrey* 6606 (G).

So. Piedmont Counties: Anson: *Correll* 1038A (D).

No. Coastal Plain Counties: Beaufort: *Blomquist* 1720 (D). Camden: *Blomquist & Williams* 1719 (D). Chowan: *Correll* 2030A (D). Edgecombe: *Alexander* (NC). Gates: *Correll* 2252 (D). Hyde: *Oosting* 25 (D). Nash: *Blomquist* 7551 (D). Tyrrell: *Anderson* 6044 (D). Wilson: *Blomquist* 6721 (D).

So. Coastal Plain Counties: Bladen: *Blomquist* 1718 (D). Brunswick: *Blomquist* 1717 (D). Carteret: *Gray* (D). Columbus: (1927) *P. O. Schallert* 537 (D). Craven: *Correll* 1453 (D). Cumberland: *Totten* (NC). Duplin: *Godfrey* 5867 (G). Harnett: *Correll* 2532 (D). Hoke: *Correll* 1128 (D). Jones: *Beaven* 464 (D). Moore: *Wright, et al.* 15 (C). New Hanover: *Munter* (G). Onslow: *Moldenke* 114 (D). Pender: *Barksdale* (NC). Richmond: *Correll* 1080 (D). Robeson: *Wherry* (P). Sampson: *Correll & Blomquist* 2568A (D). Scotland: *Smith* (D).

Oldest collection seen: Salem, 1812–21, *L. D. von Schweinitz* (P).

2a. **Lycopodium alopecuroides** var. **pinnatum** (Chapm.) Lloyd & Underw., Bull. Torr. Bot. Club **27:** 155. 1900. (*Lycopodium inundatum* var. *pinnatum* Chapm. Fl. So. U. S. ed. 1, p. 600. 1860; *Lycopodium*

prostratum Harper, Bull. Torr. Bot. Club **33:** 229. 1906) (Prostrate Foxtail Clubmoss). Lloyd and Underwood wrongly attributed the combination *Lycopodium alopecuroides* var. *pinnatum* to Chapman but they were actually the first to use it.

There is little, besides the prostrate habit, to separate var. *pinnatum* from the species. The stem of var. *pinnatum* is slender, prostrate, creeping, pinnately branched and rooting profusely on the ventral surface with the leaves usually twisted and lying in one plane; whereas, the stem of *L. alopecuroides* is rather thick, usually forked near the base into recurved or arching branches which take root at the apex, with the leaves in more than one rank and spreading radially.

The two segregates are found in similar habitats but are seldom found growing together. Variety *pinnatum* has been found in North Carolina only in the southern Coastal Plain region while *L. alopecuroides* has been found throughout both the northern and southern Coastal Plain region, in parts of the Piedmont Plateau and as far west as Henderson County in the southern Mountain Region. The species is also comparatively widespread while var. *pinnatum* is confined to the southeastern Coastal Plain from Florida to North Carolina, Louisiana, and Texas.

So. COASTAL PLAIN COUNTIES: BLADEN: *Correll & Blomquist* 2568 (D). BRUNSWICK: *Blomquist & Correll* 9508 (D). COLUMBUS: (1926) *P. O. Schallert* 537 (D). CRAVEN: *Kearney* 1930 (N). HOKE: *Correll* 7180A (D). NEW HANOVER: *Williamson* (P). ONSLOW: *Godfrey* 6460 (G). PAMLICO: *Godfrey* 6789A (G). RICHMOND: *Correll* 1081 (D).

OLDEST COLLECTION SEEN: CRAVEN: 1898 *T. H. Kearney, Jr.* 1930 (N).

3. **Lycopodium carolinianum** L. (Slender or Carolina Clubmoss). Moist seepage slopes, edge of pocosins, damp depressions in savannahs and pinelands, mostly associated with *Sphagnum* and ericaceous shrubs in intensely acid soils. Florida to Texas, north to New York; also occurring as variants in South America, Asia, Africa, Australia, and New Zealand.

So. COASTAL PLAIN COUNTIES: BLADEN: *Blomquist* 1722 (D). BRUNSWICK: *Blomquist* 1721 (D). COLUMBUS: *Griswold* (D). DUPLIN: *Correll & Blomquist* 4830 (D). NEW HANOVER: *Wood* (N). ONSLOW: *Randolph* 970 (G).

OLDEST COLLECTION SEEN: Salem, 1812–21, *L. D. von Schweinitz* (P).

4. **Lycopodium clavatum** L. (Running Clubmoss). In seepage of open rocky thicket slopes and open rocky woods in very acid soil. Newfoundland to North Carolina, west to Alaska and Washington; also Mexico, to South America, Europe, and Asia.

No. Mt. Counties: Mitchell: *Cannon* 92 (N). Yancey: *Correll* 3817 (D).

So. Mt. Counties: Buncombe: *Correll* 138 (D). Haywood: *Barksdale* (D). Jackson: *Caughey* 596 (D). Macon: *Forman* (NY). Transylvania: *Humphreys* 131 (D).

Oldest collection seen: Mitchell: 1902, *W. A. Cannon* 92 (N).

5. **Lycopodium complanatum** L. var. **flabelliforme** Fern. (Running-pine, Running-cedar). In rather dry sterile pine and upland hardwood forests, moist rocky wooded slopes and rocky seepage barrens. Newfoundland to Minnesota, south to South Carolina and Georgia.

No. Mt. Counties: Avery: *Correll & McDowell* 10915 (D). Yancey: *Biltmore Herb.* (MBG).

So. Mt. Counties: Buncombe: *Davis* (NC). Haywood: *Barksdale* (P). Swain: *Barksdale* (NC). Transylvania: *House* 5152 (NY).

No. Piedmont Counties: Burke: *Viele* 4 (D). Caswell: *Correll & McDowell* 10669 (D). Davidson: *Greene* (D). Davie: *Correll & Wherry* 11075 (D). Durham: *Blomquist* 1724 (D). Forsyth: *Schallert* 1350 (D). Granville: *Blomquist & Correll* 7669 (D). Northampton: *Leeds* 732 (D). Orange: *Correll* 5007 (D). Person: *Totten & Harbison* (NC). Stokes: *Schallert* (NY). Surry: *Wherry* (P). Wake: *Oosting* 33187 (D). Warren: *Anderson* (D).

So. Piedmont Counties: Lee: *Oosting* 3437 (D).

So. Coastal Plain Counties: Moore: *Correll* 6995 (D).

Oldest collection seen: Yancey: Slopes of Mount Mitchell, Aug. 30, 1898, *Biltmore Herb.* (MBG).

6. **Lycopodium lucidulum** Michx. (Shining Clubmoss). Moist shaded ravines along streams, moist rocky seepage slopes and in the spruce-balsam association in the mountains. Newfoundland to Minnesota, south to South Carolina, Alabama, Missouri, and Texas (?); also Japan, China, and Himalayas.

No. Mt. Counties: Alleghany: *Schallert* (G). Ashe: *Correll* 3992 (D). Avery: *Blomquist* 1727 (D). Burke: *Trudell* (P). Mitchell: *Ashe* (NC). Watauga: *Blomquist* 1728 (D). Yancey: *Biltmore Herb.* 594a (G).

So. Mt. Counties: Buncombe: *Correll* 29 (D). Haywood: *Smith* (D). Macon: *Oosting* 34435 (D). Swain: *Blomquist* 1726 (D). Transylvania: *House* 3669 (G).

No. Piedmont Counties: Burke: *Viele* 3 (D). Caldwell: *Harper* (NC). Durham: *Anderson* (D). Forsyth: *Correll & Butts* 5036 (D). Guilford: *Mitchell* (D). Orange: *Coker* (NC). Stokes: *Correll & McDowell* 10737 (D).

Oldest collection seen: Mitchell: Top of Roan Mt., Sept. 8, 1876, *George Engelmann* (MBG).

7. **Lycopodium obscurum** L. (Flat-branch Groundpine). In moist thickets along streams, woods and shady rocky slopes, often associated with *Sphagnum*. Newfoundland to British Columbia and the Great Lakes region, south to Alabama; also Asia.

No. Mt. Counties: Alleghany: *Blomquist & Anderson* 9905 (D). Avery: *Small & Heller* (P). Caldwell: *Huger* (NY). Mitchell: *Cannon* 90 (in part) (C). Watauga: *Wherry* (D). Yancey: *Correll* 3833 (D).

So. Mt. Counties: Buncombe: *Correll* 136 (D). Haywood: *Ashe* (NC). Henderson: *Garren* (D). Jackson: *Blomquist* 1729 (D). Macon: *Bridgers* (D). Transylvania: *Correll* (NY).

Oldest collection seen: Salem, 1812–21, *L. D. von Schweinitz* (P).

7a. **Lycopodium obscurum** forma **dendroideum** (Michx.) comb. nov. (*Lycopodium obscurum* L. var. *dendroideum* (Michx.) D. C. Eaton ex A. Gray, Man. ed. 6: 696. 1890) (Round-branch Groundpine). This segregate represents, at most, only a branch form of *L. obscurum*. It is usually found in more open situations than the former. This added exposure to sunlight may account for the less luxuriant growth and difference in branch form of forma *dendroideum* from *L. obscurum*. Newfoundland to Alaska and Washington, southward in the mountains and Piedmont Plateau to North Carolina.

No. Mt. Counties: Ashe: *Blomquist* 9979 (D). Caldwell (or Watauga): *Durand* 12896 (C). Mitchell: *Cannon* 90 (in part) (C).

So. Mt. Counties: Buncombe: *Biltmore Herb.* 593b (F). Haywood: *Smith* (D). Jackson: *Moses* (NC). Macon: *Holland & Bridges* (NC). Transylvania: *Oosting* 34453 (D).

No. Piedmont Counties: Burke: *Correll & Blomquist* 4714 (D).

8. **Lycopodium selago** L. (Fir or Mountain Clubmoss). Found only at high altitudes in the mountains where it occurs in seepage on moist rocky barrens and in ericaceous thickets. Newfoundland to Alaska,

south along isolated peaks to North Carolina, west to Colorado and Oregon; also Greenland, Europe, and Asia.

No. Mt. Counties: Ashe: *Wherry* (P). Mitchell: *Schallert* 8213 (D). Yancey: *Leeds* (P).

So. Mt. Counties: Buncombe: *Correll* 7290 (D). Haywood: *Blomquist* 1730 (D). Jackson: *Blomquist* 1732 (D).

No. Piedmont Counties: Iredell (?): *Hyams* (Minn).

Oldest collection seen: Devil's Court House, 1843, *Asa Gray* (NY).

8a. **Lycopodium selago** var. **patens** (Beauv.) Desv. Shaded rock ledges, crevices in cliffs and rocky slopes. Newfoundland to Wisconsin, south to South Carolina and Alabama.

No. Mt. Counties: Ashe: *Wherry* (P). Burke: *Wherry* (P). Mitchell: *Redfield* (P). Rutherford: *Leeds* 96 (P).

9. **Lycopodium tristachyum** Pursh (Ground-cedar, Northern Running-cedar). In seepage of open rocky thicket slopes and in rather dry open woods. Newfoundland to James Bay and Minnesota, south along the Appalachian Mountains to Alabama; also Europe.

No. Mt. Counties: Avery: *Atkinson* 12897 (C). Wilkes: *Schallert* 852 (D). Yancey: *Biltmore Herb.* 2663a (G).

So. Mt. Counties: Buncombe: *Correll* 137 (D). Haywood: *Barksdale* (D). Jackson: *Blomquist* 1733 (D). Macon: *Trentham* (D). Swain: *Thomasson* (NC).

Oldest collection seen: Mt. Pisgah, Oct. 1897, *W. W. Ashe* (NC).

Family 2. Selaginellaceae. Spikemoss Family

1. Selaginella Beauv. Spikemosses

1. **Selaginella acanthonota** Underw. (Sand Selaginella). In rather barren scrub oak sand hills on the Coastal Plain from Florida to North Carolina.

So. Coastal Plain Counties: Bladen: *Blomquist* 2867 (D). Columbus: *Leeds* 785 (D). New Hanover: *Blomquist* 2866 (D). Pender: *Benedict* (P). Robeson: *Wiegand & Manning* 50 (G).

Oldest collection seen: New Hanover: July 1892, *C. S. Williamson* (portion of type) (N).

2. **Selaginella apoda** (L.) Fernald. (Meadow Spikemoss, Creeping Selaginella). On edges of ditches, streams and lakes and on moist soil especially low pastures and meadows. Maine to British Columbia, south to Florida and Texas.

No. Mt. Counties: Ashe: *Blomquist & Anderson* 9942 (D). Caldwell: *Wherry* (P). Madison: *Oosting* 35307 (D). Wilkes: *Wherry* (P).

So. Mt. Counties: Buncombe: *Standley & Bollman* 10269 (N). Cherokee: *Oosting* 34602 (D). Clay: *Huger* (NY). Haywood: *Blomquist* 2869 (D). Henderson: *Wherry* (P). Macon: (1888)—(F). McDowell: *Williamson* (P). Polk: *Wherry* (P). Swain: *Beardslee & Kofoid* (G). Transylvania: *Oosting* 36118 (D).

No. Piedmont Counties: Caswell: *Correll & McDowell* 10674 (D). Davie: *Wherry* (P). Durham: *Blomquist* 2870 (D). Forsyth: *Schallert* (G). Granville: *Blomquist & Correll* 7650 (D). Guilford: *Schallert* 1044 (D). Orange: *Correll* 8613 (D). Person: *Correll & McDowell* 10617 (D). Rowan: *Heller* 215 (NY). Surry: *Correll & McDowell* 10784 (D). Wake: *Stites* (D). Warren: *Godfrey* 3619 (G).

So. Piedmont Counties: Gaston: *Wherry* (P). Mecklenburg: *Blomquist, Correll & Garren* 7768 (D). Stanly: *Small* (F).

No. Coastal Plain Counties: Beaufort: *Wiegand & Manning* 48 (C). Chowan: *Kearney* 1918 (N). Currituck: *Blomquist* 2868 (D). Gates: *Wherry* (P). Washington: *Correll* 1903A (D).

So. Coastal Plain Counties: Brunswick: *Blomquist & Correll* 4886 (D). Harnett: *Oosting* 1910 (D). Moore: *Correll* 6993 (D). New Hanover: *Bartram & Long* 1048 (P). Onslow: *House* 4543 (N). Richmond: *Correll* 7117 (D).

Oldest collection seen: Salem, 1812–21, *L. D. von Schweinitz* (P).

3. **Selaginella rupestris** (L.) Spring (Rock Spikemoss). On dry rock ledges and gravelly slopes or in seepage on exposed flat rock faces. Nova Scotia to Minnesota, south to Georgia, Alabama, and Texas (?).

No. Mt. Counties: Ashe: *Blomquist & Anderson* 9955 (D). Burke: *Small & Heller* 214 (Minn). Caldwell: *Small & Heller* (P). Mitchell: *Ashe* (NC). Watauga: *Heller* 214 (NY).

So. Mt. Counties: Buncombe: *Correll & Wherry* 10976 (D). Haywood: *Blomquist* 2872 (D). Jackson: *Rowe & Humphreys* 179 (D). Polk: *Peattie* 1040 (NC). Rutherford: *Wherry* (P). Transylvania: *Correll* 3383 (D).

No. Piedmont Counties: Forsyth: *Schallert* 1201 (D). Orange: *Ashe* (NC). Rowan: *Small* (NY). Stokes: *Leeds* 793 (P). Wake: *Oosting* 53 (D). Wilkes: *Blomquist & Anderson* 10026 (D).

No. Coastal Plain Counties: Franklin: *Blomquist* 6717 (D).

So. COASTAL PLAIN COUNTIES: HARNETT: *Oosting* 1907 (D).

OLDEST COLLECTION SEEN: Salem, 1812–21, *L. D. von Schweinitz* (P).

4. **Selaginella tortipila** A. Br. (*S. Sherwoodii* Underw. in part) (Rock Selaginella). Growing in mats on exposed granitic rock faces and ledges where continual or periodic seepage occurs. North Carolina, Tennessee, and Georgia.

No. MT. COUNTIES: ASHE: *Ashe* (NC). AVERY: *Hunnewell* (N). CALDWELL: *Ashe* (NC). MITCHELL: *Ashe* 1105 (NC).

So. MT. COUNTIES: HENDERSON: *Huger* (NY). JACKSON: *Blomquist* 2874 (D). MACON: *Blomquist* (D). POLK: *Townsend* 17 (C). RUTHERFORD: *Leeds* 73 (P).

No. PIEDMONT COUNTIES: BURKE: *Blomquist & Correll* 4712 (D).

OLDEST COLLECTION SEEN: BURKE: Table Rock, 1839, *Rinehart* 265 (P).

ORDER VI. ISOETALES

FAMILY 1. ISOETACEAE. Quillwort Family

1. ISOETES L. Quillworts

1. **Isoetes Engelmanni** A. Br. (Appalachian Quillwort). In sluggish ditches, canals, and streams, and on the margin of ponds and lakes. Alabama to New Hampshire and Maine, west to Missouri.

So. MT. COUNTIES: BUNCOMBE: (1898) "base of Craggy Mt." (MBG). HAYWOOD: *Blomquist* 1709 (D). HENDERSON: *Oosting* 3676 (D). JACKSON: *Wherry* (P). MACON: *Bold* (NC). POLK: *Biltmore Herb.* 5564 (G). SWAIN *Beardslee & Kofoid* (G). TRANSYLVANIA: *Blomquist* 1707 (D).

No. PIEDMONT COUNTIES: GUILFORD: *Barksdale* (NC).

So. PIEDMONT COUNTIES: GASTON: *Wherry* (D).

So. COASTAL PLAIN COUNTIES: COLUMBUS: *Correll & Blomquist* 7366 (D).

OLDEST COLLECTION SEEN: SWAIN: Alt. 1700 ft., Aug. 10, 1891, *H. C. Beardslee & C. A. Kofoid* (G).

1a. **Isoetes Engelmanni** var. **caroliniana** A. A. Eaton (Carolina Quillwort). Seepage slopes and in temporary pools on granite outcrops. Georgia to North Carolina.

No. MT. COUNTIES: AVERY: *Blomquist* 10490 (D). MITCHELL: *Ashe* 1092 (MBG).

No. PIEDMONT COUNTIES: ROWAN: May 30, 1895, Salisbury, *W. W. Ashe* (NC).

So. PIEDMONT COUNTIES: GASTON: *Wherry* (P).

OLDEST COLLECTION SEEN: MITCHELL: Big Rock Creek, 1893, *W. W. Ashe* (TYPE) (MBG).

2. *Isoetes virginica* Pfeiffer. This species, which was first found in Virginia, has also been found in Georgia where it varies, however, to such an extent from the species that it has been segregated into a distinct variety (*I. virginica* var. *piedmontiana* Pfeiffer). While no specimen from North Carolina has been definitely assigned to this species, a specimen collected by W. W. Ashe, 1899, near Salisbury, Rowan County, approaches the variety of this species. This specimen is in the Herbarium of the University of North Carolina.

DEPARTMENT OF BOTANY, DUKE UNIVERSITY,
BOTANICAL MUSEUM, HARVARD UNIVERSITY.

SELECTED BIBLIOGRAPHY

ANDERSON, W. A., JR.
1929 The Ferns of Tennessee. Univ. Tenn. Record, Ext. Ser., **6**, No. 1.
BLOMQUIST, H. L.
1931 Some of the Pteridophytes of North Carolina and their Distribution. Amer. Fern. Journ. **21**: 81–90.
1934 Ferns of North Carolina. Durham, N. C.
BROUN, MAURICE
1938 Index to North American Ferns. Orleans, Mass.
CORRELL, D. S.
1938 A County-Check-List of Florida Ferns and Fern Allies. Amer. Fern. Journ. **28**: 11–16, 46–54, 91–100.
1939 Some Southeastern Fern Notes. Amer. Fern. Journ. **29**: 135–142.
LOWE, E. N.
1921 Plants of Mississippi. Miss. St. Geol. Surv. Bull. **17**: 59–64.
MOHR, C.
1901 Plant Life of Alabama. Contrib. Nat. Herb. **6**: 310–322.
SMALL, J. K.
1913 Flora of the Southeastern States. 2nd. ed. New York.
1931 Ferns of Florida. New York.
1938 Ferns of the Southeastern States. Lancaster, Pa.
WEATHERBY, C. A.
1935 A List of Varieties and Forms of the Ferns of Eastern North America. Amer. Fern. Journ. **25**: 45–51, 95–100.
1936 Ibid., **26**: 11–16, 60–69, 94–99, 131–136.
1937 Ibid., **27**: 20–24, 51–56.

SPECIES OF OEDOGONIUM NEW TO SOUTH CAROLINA*

By P. J. Philson

Seven Text Figures

Oedogonium foveolatum Wittr. Fig. 1.

Monoecious; oogonia 1 or 2, obovoid to subellipsoid-globose, with superior pore; oospore globose to subellipsoid-globose, filling or not filling oogonium; outer spore-wall scrobiculate; antheridia 1–7; sperms two, division horizontal; basal cell elongate, terminal cell apically obtuse; vegetative cell 14–23 by 35–115 mu; oogonium 37–49 by 38–61 mu; oospore 33–46 by 34–53 mu; antheridium 12–19 by 5–12 mu.

This alga, in the fruiting stage, was collected on July 2, 1932, from Alligator Lake, Myrtle Beach, South Carolina. The plants formed plumose masses on dead twigs a few inches below the surface of the water. Material sent to Dr. L. H. Tiffany was verified by him as belonging to this species. The species is easily identified due to two specific characters, namely, the scrobiculate structure of the oospore wall, and its monoecious character.

Collection number 2.

Oedogonium sexangulare Cleve. Fig. 3.

Dioecious, nannandrous, gynandrosporous; oogonium 1 (rarely 2), sexangulare-ellipsoid, pore a little above median; oospore same form as oogonium and nearly filling it; spore-wall smooth; suffultory cell sometimes slightly tumid; androsporangia 1–3; dwarf male on suffultory cell, a little curved, stipe of 2–3 cells; antheridium exterior, 1; vegetative cell 9–16 by 30–110 mu; oogonium 29–33 by 33–39 mu; oospore 27–31 by 31–36 mu; androsporangium 13–14 by 10–14 mu; dwarf male stipe 7–9 by 21–30 mu; antheridium 6–7 by 9–12 mu.

A collection of this species was received on June 8, 1938. According to information received with the sample, it was collected from one of the untreated storage basins of the municipal water plant at Greenwood,

* The species descriptions contained in this paper are taken from Tiffany, L. H., The Oedogoniales. N. A. Flora. **11**: 1–101. 1937.

S. C. The angular (sexangular-ellipsoid) character of the oogonial wall serves readily to distinguish this species from all others of the genus. The cells from this collection measured 9.6–17 by 40–87 mu; the oogonia 30–38 by 34–45 mu; the oospores 28–37 by 32–42 mu; the stipe of the dwarf male 7–8.5 by 23–31 mu; and the antheridia 6.4–6.8 by 9.6–12.2 mu. In a few cases, the measurements were slightly over those for the typical species, but these few cases were not of sufficient importance to warrant further consideration.

Collection S.C. 86.

Oedogonium intermedium Wittr. Fig. 5.

Monoecious; oogonium 1, obovoid to obovoid-globose, pore superior; oospore globose or obovoid-globose, filling oogonium or nearly so; spore-wall smooth and thick; antheridia 1–4, epigynous or subepigynous or hypogynous or rarely scattered; sperms 2, division horizontal; vegetative cell 15–18 by 45–80 mu; oogonium 31–37 by 34–45 mu; oospore 30–36 by 33–41 mu; antheridium 14–16 by 5–10 mu.

On July 18, 1933, the author observed a feathery mass of a brownish green alga, attached to the submerged petioles of the Pickerel-weed, *Pontederia cordata* L., growing in a lily pool of the author's home at Gaffney, S. C. Further study placed these algal plants in this species. The location of the antheridia, the monoecious character of the plants, and the superior pore serve as distinguishing features of the species.

Collection S.C. 59.

Oedogonium Borisianum (Le Clerc) Wittr. Fig. 4.

Dioecious, nannandrous, gynandrosporous or idioandrosporous; oogonia 1–5, obovoid or quadrangular-ellipsoid, pore superior; oospore ovoid to obovoid (often quadrangular-ovoid), not filling oogonium; spore-wall smooth; androsporangia 1–7, usually in the upper part of the filament; basal cell elongate; terminal cell, often an oogonium, broadly apiculate, obtuse, or sometimes setiferous; suffultory cell swollen; dwarf male somewhat curved, on suffultory cell; antheridia 2; vegetative cell sometimes capitellate, 15–23 by 45–140 mu; suffultory cell 31–38 by 50–92 mu; oogonium (33) 40–50 by 55–90 mu; oospore 35–46 by 48–60 mu; androsporangium 16–19 by 15–23 mu; dwarf male stipe 12–18 by 35–47 mu; antheridium 7–10 by 11–16 mu.

On May 14, 1939, a mass of floating algae was collected from the artificial pool on the grounds of the University Gardens, Columbia, S. C.

Upon further examination, it was discovered to be a mixture of this and two other species of *Oedogonium*. The material was in excellent fruiting condition, and all measurements conformed to those typical for this species. Once carefully observed the species is not easily mistaken. Below the enlarged suffultory cell, the vegetative cells gradually decrease in diameter to a characteristic size, while those cells above the oogonium do not exhibit this difference. This peculiar variation is most striking.

Collection S.C. 85.

Oedogonium Kurzii G. Zeller. Fig. 2.

Monoecious; oogonium 1, rarely in series, obovoid to subellipsoid, pore superior; oospore subglobose or ellipsoid, not filling oogonium; spore-wall smooth; antheridia hypogynous or scattered, to 15-seriate; sperms 2, division vertical; terminal cell apically obtuse; vegetative cell 44–52 by 90–250 mu; oogonium 70–95 by 111–130 mu; oospore 67–86 by 80–93 mu; antheridium 44–52 by 6–16 mu.

This species was collected on May 14, 1939, from a pool in the University Gardens, in Columbia, S. C. It was associated with *Oe. Borisianum* (Le Clerc) Wittr. and *Oe. Wyliei* Tiffany. The large size of the filaments with their ellipsoid oospores, which do not fill the oogonia, and the monoecious character of the plants, make identification of this species not difficult.

Collection S. C. 85.

Oedogonium Wyliei Tiffany. Figs. 6–7.

Dioecious, macrandrous; oogonia 1–4, globose to ovoid, pore superior; oospore globose to ovoid, filling or not filling oogonium; outer spore-wall

---

EXPLANATION OF FIGURES

Fig. 1. *Oedogonium foveolatum* Wittr., showing a typical oogonium with the scrobiculate oospore, and location of the antheridia. × 250.

Fig. 2. *Oe. Kurzii* G. Zeller. Fruiting structures typical for the species. × 250.

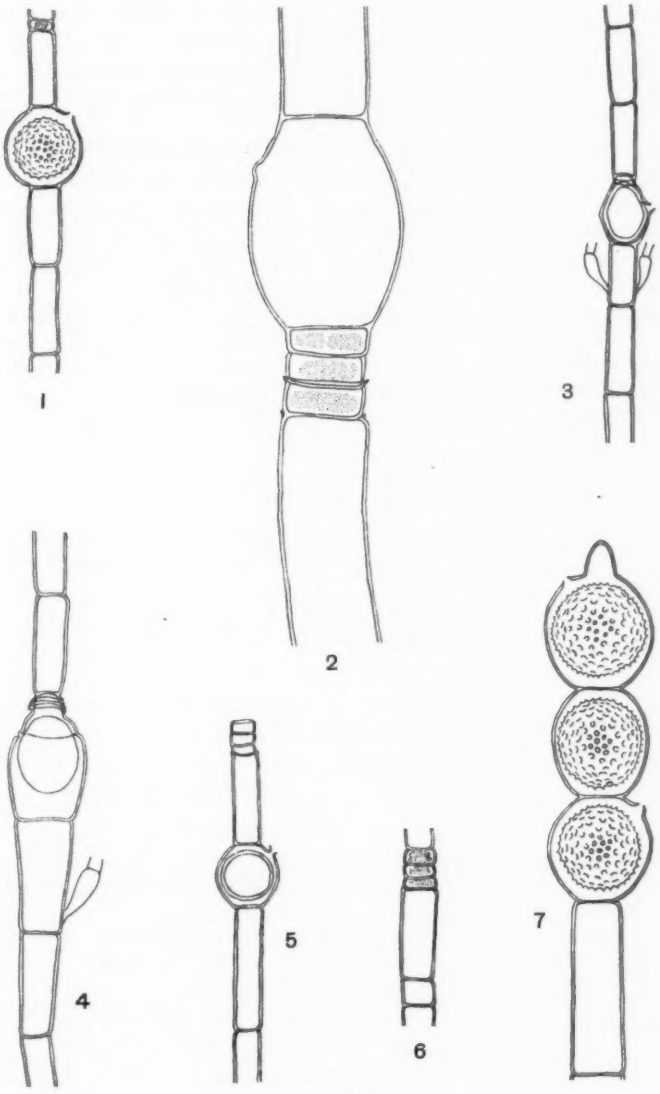
Fig. 3. *Oe. sexangulare* Cleve, showing dwarf males and oogonium. × 250.

Fig. 4. *Oe. Borisianum* (Le Clerc) Wittr. × 250.

Fig. 5. *Oe. intermedium* Wittr. × 250.

Fig. 6. *Oe. Wyliei* Tiffany, showing a portion of the male filament containing antheridia. × 250.

Fig. 7. *Oe. Wyliei* Tiffany, showing apical oogonia with scrobiculate oospores. × 250.



FIGS. 1–8

irregularly scrobiculate; antheridia 1–4; sperms 2, division horizontal; basal cell elongate; terminal cell, often an oogonium, apically obtuse or broadly apiculate; vegetative cell 16–24 by 80–170 mu; oogonium 52–64 by 68–112 mu; oospore 48–60 by 52–64 mu; antheridium 16–19 by 8–18 mu.

This species occurred intermixed with the two preceding, and with *Oe. Borisianum* (Le Clerc) Wittr. constituted most of the algal mass. A noticeable feature in this collection was the number of filaments which terminated in oogonia, the oospores of which were scrobiculate. In a few of the plants, the measurements were slightly over those for the species, but the greater number fell within this range.

Collection S.C. 85.

DEPARTMENT OF BIOLOGY,
UNIVERSITY OF SOUTH CAROLINA,
COLUMBIA.

A NEW TURBELLARIAN WORM (RHABDOCOELE) FROM BEAUFORT, NORTH CAROLINA, *Phonorhynchus pearsei* n. sp.

By F. F. Ferguson, M. A. Stirewalt, and W. A. Kepner

Plate 1 and One Text Figure

At the Beaufort Biological Station, Piver's Island, Beaufort, North Carolina, during the summers of 1938 and 1939 an undescribed species of turbellarian, apparently a member of the genus *Phonorhynchus*, was constantly collected at low tide around the island in dense masses of *Ulva*. In the spring of 1939 this species was also taken about twelve miles from Williamsburg, Virginia, at the mouth of a small creek where it empties into the York River, as well as in Taylor's Creek, Beaufort. The salinity of the water at Beaufort was three parts per thousand (3/1000), that of the creek at York River slightly less. The animals are rapid swimmers.

The expense of collecting specimens was met, in part, by a grant from the Research Committee of the Virginia Academy of Science. We are also very grateful to Dr. H. F. Prytherch, Director of the United States Bureau of Fisheries Biological Station at Beaufort, for the many privileges granted us, and to Dr. A. S. Pearse, Director of the Duke Biological Station, for whom, in appreciation of his interest in Turbellaria and the many courtesies he has extended us, we take great pleasure in naming this new species.

Phonorhynchus pearsei new species

Specimen 1.15 mm. long by 0.17 mm. wide. Ciliation uniform. Color translucent with a bilaterally divided net-work of purple pigment. Eyes black. Conspicuous proboscis. Proboscis-sheath opening ventrally and subterminally. Pharynx doliiform, its sheath opening near posterior region of anterior third of body. Renal beaker associated with mouth of pharyngeal sheath. Testes dorsolaterally disposed, elongated rods, with their ventro-mesial surfaces concave, extending from cephalic ganglia to near posterior end of pseudocoele. Conspicuous muscular vasa deferentia, one of which is looped. No vesicula seminalis. Vesicula granulorum oval containing concentrically packed refractive bent rods and supplied with relatively small glands. Stylette

compound, its basal or anterior element receiving the granular material, its posterior element receiving the ductus seminalis. Poison dart opens anteriorly with stylette into common genital atrium, there being no antrum masculinum. Gonopore single lying at anterior margin of posterior fifth of body. Common genital atrium receives female genital canal at its posterior region. Two ovaries and two long rod-like vitellaria, each of which may be lobed at its posterior end. Conspicuous receptaculum seminis borne upon posterior end of female genital canal. Lips of receptaculum armed with cuticular denticles. Two short muscular oviducts, each presenting a very muscular coecum within which is supported a unique brush-like body refractive in life. Apparently the chromosome numbers: n = 3; 2n = 6.

The species is described from numerous co-types, which have been sectioned in part and mounted on slides, of which three have been deposited in the collections of the United States National Museum (U. S. N. M. no. 20530) and two in the collections of the University of Virginia (U. V. nos. 818-4 and 818-5).

Ludwig von Graff is responsible for the genus *Phonorhynchus*. In 1882, he described a species under the name, *Macrorhynchus helgolandicus*, which in 1905 he assigned to a new genus *Phonorhynchus* as *P. helgolandicus*. Gamble (1893) says "the reproductive organs" of this species "were first described by Jensen" in his *Gyrator danielsseni*. "The great variability of certain (especially the chitinous) parts, their complexity and the presence or absence of certain accessory organs (spermatheca, etc.) according to the particular stage of development, render this perhaps the most difficult of all Turbellarians to elucidate" (p. 464). In 1913 Graff defined the genus as one of the Polycystidae with a poison apparatus opening into the male genital atrium and the vesicula seminalis entirely separate from the vesicula granulorum, each vesicula being provided with a separate cuticular tube. Graff (1913) also considered his *P. helgolandicus* to be synonymous with Mecznikow's (1865) *Prostomum helgolandicus*, Jensen's (1878) *Gyrator danielsseni*, and with Hallez's (1879) *Prostomum girardi*. Meixner (1925, p. 305) defined the genus *Phonorhynchus* Graff as follows: Polycystidae, whose male genital canal opens into the atrium caudal to the female genital canal; vitellaria branched, often netted because of anastomosis; the vitelloducts opening at the end of the female genital canal between the oviducts; the female genital canal bearing proximally a muscle-free sac ("Bursa"); and germaria typically constructed.

In certain details our species fits the diagnosis of neither Graff nor Meixner for this genus, and yet its general anatomy is such that it must be assigned to the genus *Phonorhynchus*.

ANATOMY OF SPECIMEN

The spindle-shaped body is slightly more obtuse at the posterior than at the anterior end. The length varies from 1.0 to 1.5 mm., while the mid-diameter is approximately 0.17 mm. There is a conspicuous pattern of purplish-brown pigment seen beneath the dorsal epidermis (Fig. 1). This pigment pattern presents two lateral longitudinal strips which in turn give off lateral and mesial transverse branches. The two sets of mesial branches unite to form a series of transverse irregular bands. Except for this pigment pattern, the eyes, and a yellow tint to the vitellaria and certain nidamental glands, the body is colorless. The epidermis bears a uniform coat of cilia about 8μ long. There are three pores disposed in a midline on the ventral side of the body. The most anterior of these is the pore of the proboscis-sheath which is slightly subterminal. The mouth of the pharyngeal sheath lies near the posterior margin of the anterior third of the body (Fig. 2, *ph*). The common gonopore lies near the anterior margin of the posterior fifth of the body.

The proboscis (Rüssel) (Fig. 2, *pb*) presents two regions: (1) the distal end, which is sugar-loaf shaped, bears numerous small rhabdites and lies free within a proboscis-sheath; (2) the proximal region of the proboscis which is bulbous and highly muscular, is embedded within the parenchyma. It is provided with protractor muscles and very conspicuous retractor ones.

The epidermis, in transverse sections of fixed material, measures but 3 μ in thickness. This represents a somewhat shrunken condition since rhabdites that are not discharged extend from the basement membrane to project beyond the epidermal outer surface by a fifth of their length. Within this thin cytoplasm are found small spheroidal nuclei whose diameters average about 2.8 μ. The cilia in the fixed condition are about twice as long as the epidermis is thick.

Two large dorsal ganglia (Fig. 2, *b*) connected by a very stout commissure constitute the most conspicuous feature of the central nervous system. Each ganglion gives off an anterior nerve (Fig. 2, *n*) and a posterior one.

Lying over the posterior dorsal surface of the ganglia are two black eyes. Each eye is about 15 μ in diameter. There are two retinulae in each eye.

No other organs of special sense have been observed.

Beneath the relatively thin epidermis lies a conspicuous layer of circular muscles. The peripheral longitudinal muscles are heavy

bands that lie irregularly scattered over the inner surface of the circular layer. This muscular tunic houses the viscera, which latter so crowd the pseudocoele that very few parenchymal cells may be recognized.

The alimentary canal is typical, being composed of a doliiform pharynx and a non-diverticulated enteric sac. The lining of the enteric sac is epithelial. The enteric sac is greatly crowded by the extensive vitellaria, testes and other viscera.

The excretory system is also of the usual type. Two anterior lateral and two posterior lateral branches unite to each side of the mouth to form a right and a left transverse duct (Fig. 2, *pr'*). These ducts empty into a renal vesicle ("Beaker") which in turn empties through the mouth of the pharyngeal sheath.

The male reproductive system presents two long rod-shaped testes (Fig. 2, *t*) which lie beneath the dorsolateral epidermis and extend, at maturity, from opposite the eyes to a little beyond the posterior margin of the receptaculum seminis near the posterior end of the body.

These testes are associated with two of the most conspicuous organs of this species, namely the vasa deferentia (Fig. 2, *vd*). Usually the left vas deferens is thrown into a loop. These male gonoducts resemble what have been named the false seminal vesicles of other species. In this animal, however, they lead directly from the testes to a common duct, which may be designated the ductus seminalis. The wall of the vas deferens bears a strong muscular tunic. Some of the longitudinal muscles of this tunic anchor the vas deferens with the mid-mesial region of the testis (Fig. 2, *rm*). The spermatozoon, as seen in freshly crushed material in the vicinity of a vas deferens, is a trypanosome-like object measuring approximately 75 μ in length. There are three regions to its body. An anterior one which has the form of a slender spiral object (Fig. 7, *a*); a middle region that has the form of a bent cylinder with tapering ends (Fig. 7, *b*), and a slender caudal region which bears a low undulating membrane (Fig. 7, *c*). When not swimming this cell tends to sit upon its caudal region's end as it sways to and fro.

As indicated above, the union of the two vasa deferentia results in the formation of a slender ductus seminalis without a vesicula seminalis (Figs. 3 and 4, *ds*). The ductus opens at an unusual level into the cuticular copulatory apparatus. This apparatus (Fig. 2, *s*) is compound consisting of a cuticular tube which is somewhat funnel-shaped (Fig. 4, *a*), and a second more slender cuticular tube (Fig. 4, *b*) which

articulates with the posterior end of the funnel-shaped one. The anterior end of the former receives the vesicula granulorum and serves as a transporting duct for the granular material. The vesicula granulorum (Figs. 2 and 3, *vg*) contains numerous refractive, slightly bent, spindle-shaped bodies, which may be the granular material for they resemble the refractive rods that are found within the vesicula granulorum of *Dalyellia microphthalmia* Vejdovský (1895) and other rhabdocoeles. The glands that are usually associated with the free end of the vesicula granulorum are small in this form. The funnel-shaped cuticular duct (Fig 4, *a*) of the vesicula granulorum articulates with the anterior end of the second cuticular duct. This duct (Fig. 4, *b*) tapers to a bent point posteriorly and is marked by a set of heavy, cuticular ridges, which, in a general manner, range along the surface as a spiral. Near the apex these ridges converge to form a projecting recurrent, flattened spur (Fig. 4, *f*). This second tube receives at its anterior end the ductus seminalis and, as stated above, the cuticular duct of the vesicula granulorum. It serves, therefore, as a pathway for both male gametes and granular material. This compound cuticular apparatus opens into the genital atrium at its anterior region.

The genital atrium (Figs. 2 and 3, *ga*) is relatively small. It has a muscular wall and is supplied with nidamental glands.

The so-called "poison dart" that has been described for the genus *Phonorhynchus* is in this case 122 μ long (Fig. 2, *pd*). It lies by the left side of the penis. This structure consists of a very slender, somewhat bent cuticular tube, and an oval glandular mass that is borne upon the free end of the cuticular tube. We have made no observations that will throw light upon the method in which this "poison dart" functions.

The female reproductive system consists essentially of a pair of ovaries and associated accessory organs. The female genital canal (Fig. 3, *fgc*) leads off from the posterior wall of the genital atrium. Two short oviducts (Fig. 2, *co*) connect the terminal lateral angles of the female genital canal to the ovaries. Each oviduct expands as a funnel (Fig. 5, *f*) over the mesial basal region of the ovary. Into the fundus of this funnel of the oviduct a vitelloduct (Figs. 2 and 5, *vtd*) empties. Each vitelloduct is attached to a large rod-shaped vitellarium (Figs. 2 and 3, *v*) that lies ventro-mesially by the testis. Each vitellarium is lobed along its mesial side posterior to the receptaculum seminis.

A conspicuous feature of *P. pearsei* is the receptaculum seminis (Figs. 2 and 3, *rs*), which is a spheroidal sac at the free end of the female

genital canal. The general wall of this sac is supplied with few muscles. Its mouth, however, is guarded by a dorsal and a ventral heavy muscular lip (Fig. 6, *l*). These lips bear cuticular denticles or spines (Fig. 6, *sp*), which in life are thrown into a champing motion that suggests the champing of the "hammers" of a rotifer's mastax.

Perhaps the most unusual feature of *P. pearsei* is presented by the oviduct. Each oviduct bears a mouth or funnel (Fig. 5, *f*) that is in part confluent with the membrane that encloses the ovary. The main part of the short oviduct is muscular in its antero-dorsal region (Fig. 5, *m*). This muscular wall is thrown, postero-ventrally, into a very highly muscular coecum or sac (Fig. 5, *s*). The lumen of this muscular coecum[1] bears the slender handle of a cuticular brush (Fig. 5, *co*). The ten or more short, stout teeth of the brush project into the lumen of the oviduct. The brushes of the oviducts, by swinging towards and away from each other, have been observed in life to throw spermatozoa away from and into the champing teeth of the mouth of the receptaculum seminis.

The terms bursa copulatrix, bursa seminalis and receptaculum seminis are rather loosely used in the literature. Graff (1913, p. 338) designated the presence of a bursa copulatrix as being a diagnostic feature of the genus *Phonorhynchus*. In 1882 in his original description of *Macrorhynchus helgolandicus*, which later he described as *Phonorhynchus helgolandicus*, Graff named this organ a bursa seminalis (Taf. IX, Fig. 28). We have made a brief survey of the literature concerning these two types of bursae. We find that they are usually described as outgrowths of genital atria and not of either oviducts or female genital canals. The receptaculum seminis, on the other hand, is described usually as a modification of either the oviduct or as an outgrowth from the female genital canal. Vejdovský (1895) has described a receptaculum as being an appendage of the fundus of the vagina of *Dalyellia microphthalmia*.

Kepner, Ruebush and Ferguson (1937) have described a typical receptaculum seminis in *Castrada virginiana*. In this case it is little more than a modified region of an oviduct. This appendage of the female genital canal of *C. virginiana*, as it pends from between two short oviducts, is clearly the homolog of the well-defined appendage of

[1] These oviducal coeca appear to be homologous with the "Nebentaschen" of the bursa seminalis that Graff (1882) had described for *Macrorhynchus helgolandicus*.

the female genital canal of *P. pearsei* which we have named the receptaculum seminis.

We make the suggestion, therefore, that the presence of a well defined receptaculum seminis be given as a diagnostic feature of the genus *Phonorhynchus* instead of the presence of either a bursa copulatrix or a bursa seminalis. Our species of this genus is peculiar in that a) it has a dolioform instead of a rosulate pharynx; (b) there is no antrum masculinum, and (c) the vitellaria are rod-like instead of being netted.

SPECIAL OBSERVATIONS

The spermatozoa in smear preparations, are relatively stout gametes (Fig. 7). No evidence of such slender gametes can be found in the fixed and sectioned material. Sections of testes and gonoducts contain only small, rounded chromatic bodies which have the appearance of spermatids. These stained spherules may be chromatic bodies contained within the mid-region of the sperm-cells. The great abundance of these spermatozoa is a striking feature of the sectioned specimens.

We have observed specimens repeatedly copulate within a brief period. The abundance of spermatozoa may be correlated with this conduct. In one case, one animal exchanged spermatozoa with two other specimens within fifteen minutes. In a Petri dish, that contained twenty or more specimens, it was observed that one individual may take up and follow the trail of another. The one that was being trailed assumed a heart-shaped contour when touched on the posterior end by its pursuer.[2] This contour was effected through the invagination of the posterior end of the animal. Under this invaginated region of the body the pursuer glided. Thereupon the two animals, now elongated, glided, rotated with their ventral surfaces in opposition until their "heads" were directed oppositely as they lay upon their sides. In this position each stylette was everted into the everted female genital canal of the opposite animal. Copulation, therefore, involves, in this form, not only the extrusion of the male copulatory organ but also the extrusion of the female genital canal.

Perhaps the most interesting feature of this rhabdocoele is the structure of its proboscis (Rüssel). The histological continuity of the free end of the proboscis with the epithelium and musculature of the gen-

[2] At this reaction some substance is thrown into the water; for after this reaction was displayed other specimens turned and travelled towards the pair that was involved.

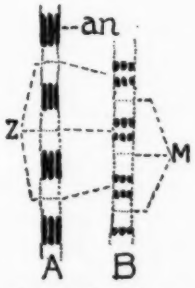
eral body suggests that the proboscis is but a modified region of the body. Within the body three sets of non-striated muscles are found: (1) circular muscles that lie just beneath the epidermis; (2) longitudinal ones that lie next to the circular ones, and (3) heavy strands that extend in various directions throughout the pseudocoele. These three sets of muscles and the epidermis of the body have been involved in the formation of the proboscis.

The thin epidermis of the general surface has been invaginated and modified to become the lining of the proboscis sheath (Fig. 8, *s ep*). This, in turn, is confluent with the rather heavy epithelium that covers the free end of the proboscis (Fig. 8, *p ep*). Radiating within the body of the proboscis from its anterior end to the base are many non-striated muscles. These von Graff has designated the radial muscles. These radial muscles function as depressors (Fig. 8, *rm*). Bundles of non-striated muscles extend from the base of the proboscis into the pseudocoele. These are the retractor muscles (Fig. 8, *rtm*). Both the depressors and the retractors appear to be homologous with the non-striated muscles that extend obliquely through the parenchyma of the body-proper.

The proboscis at rest displays muscular activity that differs but little from that of the body-proper. In each region a tonus is maintained. Both the retracted proboscis and the body-proper display a certain tonus that is maintained by the non-striated muscles. These muscles may also throw the body-proper and the resting proboscis into a slow peristalsis. The proboscis, however, at discharge stands in sharp contrast functionally with these regions under non-striated muscular control. It may be discharged and elongated with great velocity. It is interesting, therefore, to find that the muscles responsible for the rapid extension of the proboscis are striated. These extensors (Fig. 8, *em*) lie at right angles to the axis of the proboscis and the body-proper. They appear to be homologous with the non-striated circular muscles of the body-proper. It is also of interest to observe that the muscles that are responsible for the discharge of the proboscis from the sheath are also striated. These protractors (Fig. 8, *pm*) lie parallel to the axis of the proboscis and body-proper. They appear to be homologous with the non-striated longitudinal muscles of the body-proper.

So far as we are able to determine, the literature on Turbellaria records but two examples of striated muscle. Von Hofsten (1918, s. 14–15) found that the longitudinal muscles, associated with the epidermis of *Otoplana intermedia*, were distinctly striated. He could

recognize, however, only the anisotropic elements but no isotropic features. Maristo (1938, s. 17) observed striations in the longitudinal muscles of *Monocelis unipunctata*, recognizing, however, neither the elements of the anistropic bands ("das anisotropen Teils") nor the features of the isotropic bands. We have been able to see in our specimens the elements of the anisotropic bands (Text figure 1, A, *an*) together with the "Z" stripes (z) of the isotropic bands in the non-contracted fibers and the divided anisotropic elements and the "M" stripes (B, M) in the isotropic bands of the contracted muscle fibers. The elements of the anisotropic bands of the non-contracted muscles are about 0.4 μ long. Our observations have thus indicated that non-striated muscles of a Turbellarian may be transformed into typical striated muscles.



TEXT-FIGURE 1. Portions of two fibers from protractors of proboscis. A, extended condition; B, contracted condition. *an*, elements of anisotropic band; M, "M" stripes of contracted condition; Z "Z" stripes of extended condition. × 10,000.

The observations of von Hofsten and Maristo lead us to infer that *Otoplana intermedia* and *Monocelis unipunctata* are worms that have the faculty to contract their elongated bodies very quickly. We have searched the respective papers of von Hofsten and Maristo and have found no record of such faculty being displayed by either worm. It will be of interest to check our inference by observation. Their work does show that what in all other described Turbellaria is a layer of non-striated muscle has become or is replaced by a layer of striated muscle. It has been observed in this laboratory that *Klattia virginiensis* K. F. S.,[3] shows striated muscles associated with its very active proboscis.

[3] *Klattia virginiensis* had been mistaken for *Polycystis goettei* Bresslau until a careful study had been made of the Virginia specimens by Kepner, Stirewalt, and Ferguson. 1939-b, Zool. Anz. **125**:299-309.

The well developed proboscis (Rüssel) of the Kalyptorhynchia, *Klattia virginiensis* and *Phonorhynchus pearsei*, in their great speed of eversion and elongation, place a peculiar demand upon the two layers of non-striated muscles of the body-proper from which they have been derived. This demand was met by *some* of the non-striated circular muscles of the body-proper becoming the striated extensors of the proboscis, and by *some* of the non-striated longitudinal muscles of the body-proper becoming the striated protractors of the proboscis. It may be that a similar demand has been placed upon *Otoplana intermedia* and *Monocelis unipunctata* which they have met through the *entire* layer of longitudinal muscles becoming striated.

ABSTRACT

It is shown that to include the new species, *Phonorhynchus pearsei*, Meixner's description of the genus, *Phonorhynchus*, must be modified in two respects, namely: (1) the "vitellaria branched, often netted because of anastomosis" should read branched, or unbranched, etc., and (2) instead of a "Bursa" being present, it should be indicated that either a bursa or a receptaculum seminis may be present. Very unusual gonoducts and accessory or nidamental structures are described. A report of the sexual activity of the species is recorded. The protractor and extensor muscles of the proboscis are striated. All other muscles of the body are non-striated. Chromosomes: n = 3; 2n = 6.

MILLER SCHOOL OF BIOLOGY,
UNIVERSITY OF VIRGINIA,
CHARLOTTESVILLE, VA.

LITERATURE CITED

BRESSLAU, ERNST
1933 *In* Kukenthal, Willy, and Thilo Krumbach, Handbuch der Zoologie. Walter de Gruyter and Co. Berlin u. Leipzig.

GAMBLE, F. W.
1893 Contributions to a knowledge of British Marine Turbellaria. Quart. Journ. Micr. Sci. **34:** 433–528, tab. XXXIX–XLI.

GRAFF, LUDWIG VON
1882 Monographie der Turbellarien. I. Rhabdocoelida. **1:** 328. Wilhelm Engelmann, Leipzig.
1905 Marine Turbellarien Orotovas und der Küsten Europas. II. Rhabdocoela. Zeit. wiss. Zool. **83:** 82, Taf. 2, f. 3, 4.
1913 Turbellaria II. Rhabdocoelida. *In* Das Tierreich, Lfg. 35. R. Friedlander u. Sohn. Berlin.

HALLEZ, P.
1879 Contributions à l'histoire naturelle des Turbellariés. Travaux de l'Inst. Zool. de Lille et de la Station maritime de Wimereux 2(4): 1–213.
VON HOFSTEN, ALEX
1918 Anatomie, Histologie und Systematische Stellung von *Otoplana intermedia* du Plessis. Zool. Bidrag fr. Uppsala **7:** 1–74, Taf. 1–11.
JENSEN, O.
1878 Turbellaria ad litora Norvegiae occidentalia. Turbell. ved Norges vestkyst. Tilkjendt Bergens Museums Prisbelnning. Bergen.
MARISTO, L.
1938 Beiträge zur Kenntnis der Monocelidinen Turbellaria, Alloeocoela. Ann. Zoologici Soc. Zool. -Bot. Vanamo **6:** 1–69, Taf. I.
MEIXNER, J.
1925 Beitrag zur Morphologie und zum System der Turbellaria-Rhabdocoela. I. Die Kalyptorhynchia. Zeit. Morph. Ökol. Tiere **3:** 255–343.
METSCHNIKOW, E.
1865 Zur Naturgeschichte der Rhabdocoelen. Arch. Naturgesch. 31 Jahrg., H. I: 174–181.
VEJDOVSKÝ, F.
1895 Zur vergleichenden Anatomie der Turbellarien (Zugleich ein Beitrag zur Turbellarien-fauna Bohmens). Zeit. wiss. Zool. **60:** 90–214, Taf. IV–X u. 5 textfig.

EXPLANATION OF PLATE 1

Fig. 1. Dorsal aspect of a moving specimen × 50.

Fig. 2. Dorsal aspect of a reconstruction based upon holotypes. *b*, "brain" or dorsal ganglia; *co*, brush of oviduct; *ga*, genital atrium; *n*, anterior nerve; *o*, ovary; *pb*, proboscis (Rüssel); *pd*, poison dart; *ph*, pharynx; *pr*, anterior limb of right protonephridium; *pr'*, main stem of right protonephridium; *rm*, muscles anchoring vas deferens to testis; *rs*, receptaculum seminis; *s*, stylette; *t*, testis; *ut*, uterus; *v*, vitellarium of right side; *vd*, vas deferens, and *vg*, vesiculum granulorum. × 125.

Fig. 3. Right aspect of reconstruction of posterior half of holotypes. *ds*, ductus seminalis; *fgc*, female genital canal; *ga*, genital atrium; *lvd*, left vas deferens; *o*, ovary; *pd*, poison dart; *ph*, pharynx; *phg*, pharyngeal glands; *rs*, receptaculum seminis; *s*, stylette; *u*, uterus; *ug*, uterine glands; *v*, vitellarium of left side, and *vg*, vesiculum granulorum. × 125.

Fig. 4. Stylette as seen in a freshly crushed specimen. *a*, anterior cuticular duct into which the vesicula granulorum empties; *b*, the posterior cuticular duct showing the ductus seminalis, *ds*, emptying into it; *f*, a recurrent cuticular flange. × 650.

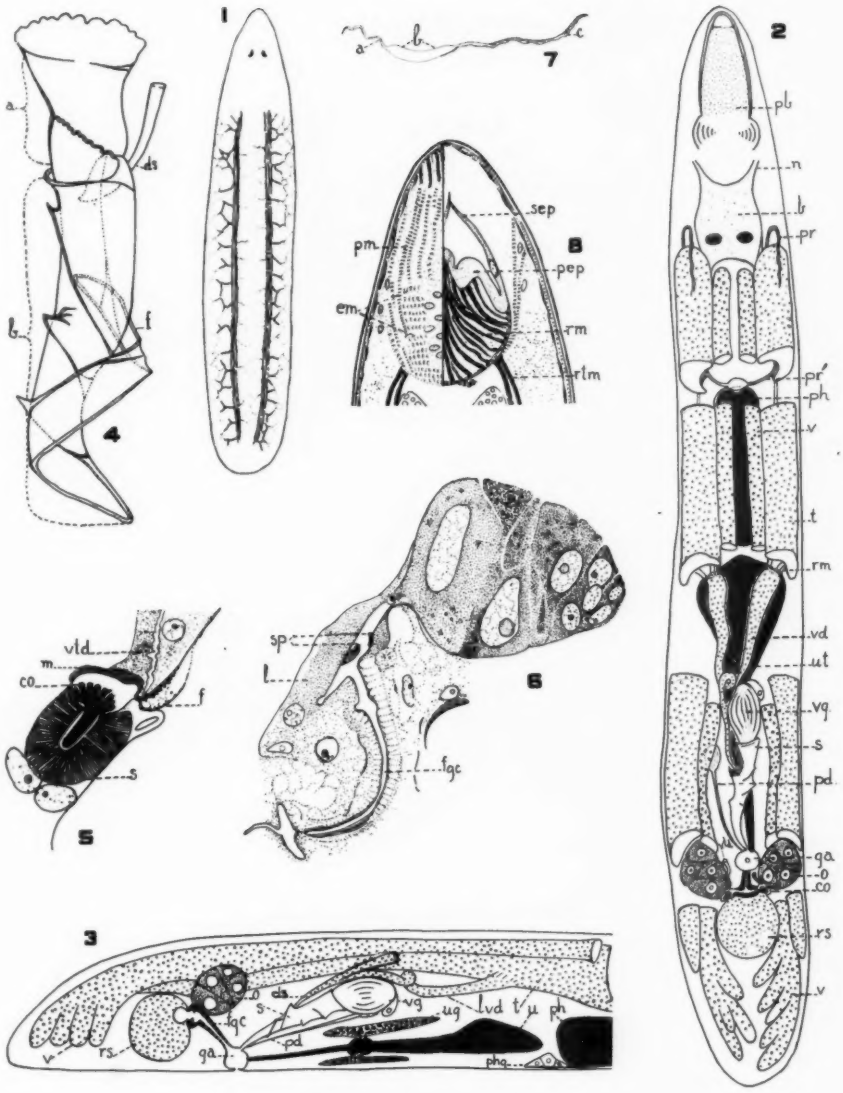
Fig. 5. Oviduct shown in section. *co*, brush; *f*, funnel; *m*, muscular dorsal wall; *s*, muscular sac of ventral wall; and *vtd*, vitello-duct. × 1000.

Fig. 6. Section involving ovary; *fgc*, female genital canal; *l*, lip of receptaculum seminis, that bears spines, *sp* × 750.

Fig. 7. A spermatozoon taken from a fresh smear. *a*, undulating anterior region; *b*, mid-region; and *c*, posterior filament bearing an undulating membrane. × 750.

Fig. 8. Reconstruction of the proboscis. Dorsal aspect. *cm*, transversely disposed, striated extensor muscles; *pep*, epithelium of proboscis; *pm*, longitudinally disposed, striated protractor muscles; *rm*, non-striated radiating muscles; *rtm*, non-striated, retractor muscles; and *sep*, epithelium of proboscis-sheath. × 275.

PLATE 1


1
2
3
4
5
6
7
8
a
b
c
ds
f
sep
pm
pep
em
rm
rlm
pb
n
br
pr
pr'
ph
v
t
vd
ut
vg
s
pd
ga
o
co
rs
vld
m
sp
l
fgc
ug
lvd
t/μ
phg

A NEW TURBELLARIAN WORM (ALLOEOCOELE) FROM BEAUFORT, NORTH CAROLINA, *Archiloa wilsoni* n. sp.

By M. A. Stirewalt, William A. Kepner, and F. F. Ferguson

Plates 2 and 3 and Two Text Figures

Specimens of this species were readily taken from the muck of the bottom of the sea water of Taylor's Creek at Beaufort (salinity 30 parts per 1,000). This form is easily recognized, under a wide field microscope, by its peculiar conduct. It moves in an undulatory way, whipping the water with its arched body in an eel-like manner as it keeps its "head" and "tail" closely applied to the substratum. This undulation of the arched body is both parallel and at right angles to the substratum. The undulation is rapid, giving the impression that the animal is greatly excited. It may be that a similar mode of locomotion may have suggested to O. Schmidt (1857) the specific name of *Monocelis anquilla* which he described as moving in an eel-like manner. Not all Monocelidinae, however, display this eel-like movement, for we have encountered another representative of this sub-family which glides through the water as do most of the Turbellaria.

The expense incurred in making our collections was met in part by grants from the Virginia Academy of Science and from the Alumni Research Fund of the University of Virginia. The collection and study of living specimens was made possible by the facilities placed at our disposal in the Laboratory of the United States Bureau of Fisheries by the director, Dr. Herbert Prytherch. This laboratory yet bears the imprint of the life of the late Dr. H. V. Wilson who had so long worked there and for it. The authors wish, therefore, to name this new species after this highly respected American zoologist.

Archiloa wilsoni new species.

Specimen 2.5 to 3.0 mm. long by 0.2 to 0.3 mm. wide. General shape of body is cylindrical, the anterior end being obtuse, the posterior end abruptly narrowing to the base of a steep conical process or caudal region. The posterior region, together with the caudal spine, bears dermal papillae with adhesive glands and packets of rhabdites. Ciliation, short and uniform. Colorless. "Head" marked by a shallow

transverse sensory groove lacking differential ciliation. A conspicuous statocyst, with three—one anterior, large, and two posterior, small—statoliths resting upon the antero-dorsal surface of the commissure of the cephalic ganglia. Pharyngeal sheath opening near anterior region of posterior third of body. Pharynx, long, cylindrical, plicate, and lying nearly horizontally. Protonephridia a pair of lateral tubes. Numerous follicular testes lying ventral to enteron from posterior margin of cephalic ganglia to near base of pharynx. Bulb of pear-shaped penis contains vesicula granulorum and vesicula seminalis. Ductus ejaculatorius armed with many rose-thorn-like denticles. Mouth of penis armed with a zone of slender, needle-like spines. Male genital antrum small, penis opening into it through its posterior wall. A glandular organ [Beauchamp's (1910) oötype and vagina; Graff's (1913) bursa seminalis] opens through the anterior wall of the male genital antrum. Two ovaries extend anteriorly within pseudocoele from near base of pharynx. Two slender rod-like vitellaria dorso-laterally situated. A vertical vitello-duct drops down from each vitellarium into the anterior end of each of the two oviducts. The anterior end of each oviduct is more or less expanded to form a receptaculum seminis. Oviducts unite just posterior to the pharyngeal sheath to form a female genital canal. This canal passes by right side of penis to open to the exterior through the female gonopore, that lies just behind the penis. Chromosome number, apparently n = 5; 2n = 10.

The genus *Archiloa* was established by Beauchamp (1910) as a representative of the family Monocelididae of the order Alloeocoela. Graff (1913) and Bresslau (1933) have assigned it to the sub-family Monocelidinae. In placing it in this subfamily, they had to overlook some of the details of Beauchamp's description; for it is characteristic of this subfamily that each of its species has a bursa seminalis. Beauchamp described no bursa. He, however, depicted a spheroidal organ that lay anterior to the male genital antrum and opened into it by means of a cylindrical tube that he designated the vagina. The spherical organ he called the oötype. Into this oötype he "arbitrarily" (p. 217) showed the oviduct emptying. Graff could not follow this interpretation and considered it to be a bursa seminalis (p. 441). Beauchamp observed that the lumen of the "oötype" was frequently filled with a finely granular refringent substance thus suggesting that it might have been a gland rather than a bursa. We have seen at no time spermatozoa in this organ, which for the present we call a bursa (Fig. 1 and 3, *b*). Apparently it is rather of the nature of a gland. Therefore, instead of separating the two genera of Graff's (p. 423) second group of the Monocelidinae by the position of the bursa, as is done at present, we propose that *Monocelis* and *Archiloa* be distinguished by the presence,

Cotypes: United States National Museum. U. S. N. M. #20563.

Tabulated Comparison of Archiloa species

	Archiloa spinosa Maristo, 1938 *Monocelis spinosa* Jensen 1878 *Monocelis unipunctata* Bresslau 1933	*A. rivularis*	*A. wilsoni*
Body length	2.0–3.7 mm.	4.0–5.0 mm.	2.5–3.0 mm.
Adhesive organs	present	present	only in posterior
Color	dirty gray	bright, translucent	colorless
Statocyst	with 1 pr. of otoliths	with 2 prs. of otoliths	with 1 large, and 2 small otoliths
Rhabdites	present	numerous	only in posterior
Head glands	few	many	few
Mouth	beginning of last body-third	mid-body	beginning of last body-third
Vesicula granulorum	same size as vesicula seminalis	4 × width of vesicula seminalis	slightly larger than vesicula seminalis
"Vagina"	opens into common genital atrium	similar	vagina absent; "bursa" opens into male genital antrum
Receptaculum seminis	present	absent	present
Bursa seminalis	slightly differentiated	"oötype"	well developed
Ductus communis	well differentiated	slightly differentiated	well differentiated

or the absence of an accessory gonopore opening exteriorly from the female genital canal, *Monocelis* having, therefore, three genital openings while *Archiloa* has but two.

ANATOMY OF SPECIMEN

The shape of the body is, in general, that of a slender cylinder, the anterior end of which is obtusely rounded while its posterior region is marked by a median spur-like process (Fig. 1, *s*). No conspicuous pigmentation is present. The specimen, seen by reflected light, is white. It is covered by a uniform coat of short cilia. There are no generally distributed rhabdites, but large packets of rhabdites (Fig. 2) are embedded in the posterior region. Both the posterior region and its spur bear dermal papillae, adhesive in function, which are from

11 μ to 12 μ long (Fig. 1, *dp*). Three pores open to the exterior along the mid-ventral line. These are the mouth of the pharyngeal sheath (Fig. 3, *mphs*); the male gonopore (Fig. 1 and 3, *mgp*); and the female gonopore (Fig. 1 and 3, *fg*). The epidermis of the living specimen is but a thin layer of finely granular cytoplasm. Transverse sections, likewise, give the impression that the epidermis is a thin (about 1.5 μ thick) layer of finely granular cytoplasm (Fig. 4, *ec*). Tangential sections of this epidermal cytoplasm show that it is actually a mosaic of thin polygonal plates that are perforated by ducts of unicellular glands. Nuclei have not been observed in this epidermal layer of cilia-bearing cytoplasm; nor have we been able to find cytoplasmic strands connecting nuclei within the parenchyma with this peculiar epidermis. It is inferred, however, that the nuclei of the epidermis lie beneath the muscularis. It appears that all of the Monocelidinae have this type of epidermis. It is of interest to record that this type of epidermis is also encountered in the triclad pharynx (Midelburg, 1908, p. 82).

Peculiar basophilic glandular products (Fig. 4, *ds*), extruded between the cilia, are seen in all of our sectioned specimens. These can be traced to irregular glandular regions (Fig. 4, *sc*) that lie beneath the muscularis.

Very conspicuous glands open to the exterior from the tips of the caudal papillae. The papillae have been observed by us as they were intimately attached to the substratum by the products of these specialized dermal glands.

There are no ciliated pits; but a transverse, ciliated groove marks off what may be taken to be the cephalic region. Though this groove bears no special cilia, it may be sensory in nature.

A pair of cephalic ganglia, connected by a stout transverse commissure lies within the pseudocoele anterior to this groove. We have traced a pair of heavy ventrolateral nerves to beyond the level of the mouth of the pharyngeal sheath. No careful study of the central nervous system has been made.

A conspicuous statocyst (Fig. 1, *st*) lies upon the antero-dorsal surface of the transverse neural commissure. A peculiar feature of this statocyst is the fact that there are three statoliths. The larger one lies in the mid-line near the anterior wall of the statocyst. The two smaller ones lie in the transverse axis one on each side. These statoliths appear to be intracellular products; for in some cases we have observed, applied closely to a statolith, what we have taken to be a necrotic nucleus. Except for the transverse ciliated groove and the statocyst, we have observed no organs of special sense.

Circular muscles lie immediately beneath the non-nucleated layer of the epidermis (Fig. 4, *cm*). These muscles show little variation in size, those of the dorsal region being not much smaller than those of the ventral region. Next to the circular muscles are longitudinal ones (Fig. 4, *lm*). These vary greatly, the ones of the ventral region being much larger than those of the dorsal region. The great development of the longitudinal muscles may be correlated with the peculiar undulatory type of locomotion displayed by *Archiloa wilsoni*.

The epidermal cytoplasm and the circular and longitudinal muscles may be considered to be a "body-wall," that houses a pseudocoele, which is so filled with viscera that but scanty parenchyma is present. We have not been able to distinguish between the nuclei that may belong to the epidermis and those of the parenchyma.

Within the pseudocoele are some oblique muscles associated with the dorso-longitudinal ones, and some, more weakly developed, which extend dorso-ventrally through the pseudocoele.

The pseudocoele houses an enteron (Fig. 1, *en*) which is an indistinctly laterally lobed sac extending from the region of the ciliated groove to the base of the spur of the body.

The epithelium of this enteron is composed, for the most part, of columnar cells that differ but little from the enteric epithelial cells of other Turbellaria (Fig. 5, *ec*). There are gland cells (Fig. 5, *gc*) which present a densely granular basal cytoplasm that houses the nucleus and a large distal region which, in the fixed condition bears many vacuoles. Each vacuole contains an oval eosinophilic granule. This type of gland occurs in the entera of many Turbellaria. The European authors refer to them as "Körnerdrüsen" or "Körnerkolben."[1]

At the posterior level of the second third of the body-length, a plicate, cylindrical pharynx opens into the enteron (Fig. 1 and 3, *ph*). The lumen of the pharynx is lined along its anterior or basal third by an epithelium that is confluent with that of the enteron. This region of the lining epithelium bears no cilia. The remainder of the lining epithelium bears stout cilia. Both this lining epithelium and the external epithelium of the pharynx present no nuclei. Apparently their nuclei have sunk beneath the muscularis. Circular and longitudinal muscles in the same order as those of the "body-wall" form the muscularis, in which the outer part is weaker than that associated with the lining epithelium. There are some radial muscles extending through the parenchyma of the pharynx.

[1] Occasional large amoeboid cells were found within the lumen of the enteron. We take these to be parasites.

Little is known concerning the excretory system of the Monocelididae. We have not been able to locate the protonephridial pores. We have observed, however, a right and left protonephridium emerging by each side of the enteron and extending to the anterior end of the pseudocoele. Each protonephridium gives off two branches within this cephalic region.

The specimens are monoecious. They resemble the Prorhynchidae in that the gonopores are distinct; but because of this they differ from the Triclads.

The male gonads are numerous. These oval follicular testes (Fig. 1 and 3, *t*) stand upon their pointed ends ventral to the enteric sack extending from the lateral side of the "brain" almost to the base of the pharynx. Each testis represents a follicle the lumen of which is crowded with cells presenting various aspects of spermatogenesis. The well advanced spermatids and the spermatozoa are attached to large "nurse-cells." A section of a "nurse-cell" with its numerous attached gametes presents a whorl-like appearance. These "nurse-cells" with their attached spermatozoa are so conspicuous in sections that one is inclined to set them up as a diagnostic feature of the species. We have seen neither vasa efferentia nor vasa deferentia.

The male copulatory organ constitutes one of the most conspicuous features of this species. This organ is a relatively large pear-shaped, muscular structure (Figs. 1 and 3, *co*). Its bulb contains the vesicula granulorum (Fig. 6, *vg*) and the vesicula seminalis (Fig. 6, *vs*). Its stem is a highly muscular cone that houses an armed ejaculatory duct (Fig. 6, *dej*). Many—ten or more—needle-like spines (Fig. 6, 7, and 8, *ns*) stand about the mouth of the ejaculatory duct while very many, small, claw-like spines are borne upon its inner surface (Fig. 6, 7, and 8, *s*).[2] There appears to be a cylinder within a cylinder in this part of the copulatory organ for we have seen, in compressed specimens, the condition shown in figures 6 and 8. The condition, shown in figure 7, was taken from a section in balsam. It will be noted that, in this series, the portion of the ductus ejaculatorius, that bears small spines, passes through the zone of needle-like spines to be partly protruded but not everted. Figure 8 depicts the protruded condition.

The spermatozoa, as seen in crushed specimens, are slender spindles about 60 μ in length. Each bears a pair of flagella at its anterior end (Fig. 9). These gametes resemble those described for other monocelids (see Midelburg, 1908, p. 96).

[2] These spines resemble those Jensen (1878) described as being present in the ductus ejaculatorius of *Monocelis spinosa*.

The penis or male copulatory organ is always present in specimens that bear a male genital antrum. The "bursa seminalis" is a variable organ being either present or absent; and it may appear as a solid sphere or as a gland with a conspicuous lumen and epithelium (Figs. 1, 3, and 7, *b*). It communicates with the the anterior region of the male genital antrum opposite the penis. We have seen no spermatozoa in this organ. This fact, together with its histology, suggests that it is rather a nidamental gland than a bursa seminalis.

The female reproductive system is in no manner connected with the male system.

Two compact, club-shaped ovaries lie near the base of the pharynx. The larger end of each ovary is directed postero-ventrally (Fig. 1 and 3, *g*). Each ovary communicates with the anterior end of an oviduct (Fig. 1, *od* and Fig. 3, *lod*). The general wall of the oviduct is composed of rather large acidophilic cells. The oviduct of the right side unites with that of the left to form a long female genital canal (Fig. 3, *fgc*). This canal arches posteriorly to pass by the right side of both the "bursa seminalis" and the penis to open through a small female gonopore that is surrounded by large acidophilic glands (Fig. 3, *ng*). The wall of the female genital canal, for two thirds of its extent, is composed of cells similar to those that form the walls of the oviducts. By the side of the penis, this canal's wall becomes very thin.

Most Monocelididae present follicular vitellaria (Midelburg, 1908, p. 96). The vitellaria of *A. wilsoni*, however, are compact and rod-shaped. They lie within the pseudocoele dorso-lateral to the enteron (Fig. 1, *v*, and Fig. 3, *lv*). Each vitellarium is connected with the anterior end of the oviduct, by a vertically disposed vitelloduct (Fig. 3, *lvd*). At the place where the vitelloduct enters the oviduct, the latter is expanded to form a small receptaculum seminis (Fig. 3, *rs*).

We have found no vagina in our specimens.

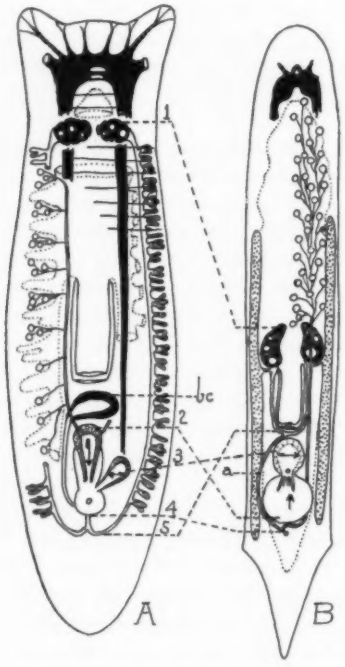
Crushed specimens, stained with acid carmine, display frequent meiotic chromosomal groups within the compressed testes. From these groups, it has been suggested that n = 5; 2n = 10 chromosomes (Fig. 10).

SPECIAL OBSERVATIONS

Otoplana intermedia du Plessis and *Archiloa wilsoni* resemble each other greatly. Each has ovaries and a statocyst, the respective positions of which are similar. The ductus ejaculatorius in each case has numerous spines that are similar, and the free end of each ductus is

surrounded by a zone of needle-like spines. Finally the plan of the reproductive systems is, in general, of the same pattern.

This general resemblance suggests to us that an homology may be seen between the posterior part of the female genital canal of *Archiloa*

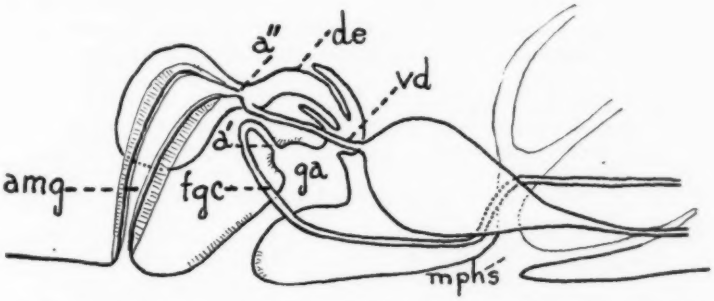


TEXT FIGURE 1. *A*. Diagram of the anatomy of a triclad. Ventral aspect. *B*. Diagram of the anatomy of *A. wilsoni*. Ventral aspect. Ovaries of *B* have shifted to position 1 in *A*; penis to position 2; "bursa seminalis" to position 3, to become the muscular gland of *B*; female gonopore has shifted, the female genital canal greatly shortened opening into genital atrium 4; the oviducts of *B* have elongated to become 5 in *A* (note respective relations of gonoducts and vitellaria): *a*, hypothetical region at which the female genital canal of *B* breaks to form the accessory male duct of *Otoplana intermedia*.

wilsoni and the unique accessory male duct of *Otoplana intermedia* du Plessis. This accessory duct leads from the ductus ejaculatorius to a conspicuous pore that opens just posterior to the penis a little to the

right of the midline. To form this accessory duct and a female genital canal, such as is present in *Otoplana intermedia,* a female genital canal such as that of *Archiloa wilsoni* may have broken at *a,* in text figure 1. The free end that lay anterior to the break entered the male genital antrum (Text-figure 2, *a'*) as does the female genital canal of *Otoplana intermedia,* whereas, the free end that lay posterior to the break, *a,* (Hofsten, p. 44, fig. 12) united with the base of the ductus ejaculatorius to become the inner fixed end (Text-figure 2, *a''*) of the accessory male duct that Hofsten (1918) described.

The anatomy of *Archiloa wilsoni* indicates an affinity between the alloeocoeles and the triclads.



TEXT FIGURE 2. Reproductive apparatus of *Otoplana intermedia* as seen from right side. *a'*, entrance of female genital canal into genital atrium; *a''*, exit of accessory male organ (*amg*) from base of ductus ejaculatorius; *de*, ductus ejaculatorius; *fgc*, female genital canal; *ga*, genital atrium; *mphs*, mouth of pharyngeal sheath; and *vd*, vas deferens. From Hofsten (1918).

For example, let the ovaries pass to the anterior region of the pseudocoele and we should have the condition that prevails in the triclads (Text-figure 1, 1). If the penis were to swing dorsally through 180 degrees we should have another triclad feature (Text-figure 1, 2). If the so-called "bursa seminalis" were to shift to the left through 90 degrees, it would assume the position of the muscular glandular organ of a triclad (Text-figure 1, 3). As has been indicated already, the anatomy of the "bursa seminalis" suggests that of a gland rather than that of a bursa. Therefore, we take this "bursa seminalis" to be homologous with the muscular gland of a triclad. The bursa copulatrix (Text-fig. 1A, *bc*) of a triclad is not represented in the anatomy of *Archiloa wilsoni.*

ABSTRACT

A third species is described for the genus *Archiloa*, to be named in honor of Dr. H. V. Wilson of the University of North Carolina who exerted great influence upon the biological work at the U. S. Bureau of Fisheries Station at Beaufort. The new species differs from Beauchamp's *A. rivularis* and Maristo's *A. spinosa* in lacking a "vagina"; in body shape and size; in the structure of the statocyst; in the position of the mouth; in the size of the vesicula granulorum; and in the morphology and relationship of the ducts of the female reproductive system.

An homology between the accessory male duct of *Otoplana intermedia* and the posterior region of the female genital canal of the new species may be indicated. Homologies between anatomical features of the new species and the triclads are also suggested.

MILLER SCHOOL OF BIOLOGY,
UNIVERSITY OF VIRGINIA,
CHARLOTTESVILLE, VA.

LITERATURE CITED

BEAUCHAMP, P. DE
1910 *Archiloa rivularis* n. g., n. sp. Turbellarié Alloeocoele d'eau douce. Bull. Soc. Zool. France **35:** 211–219.

BEKLEMISCHEV, W. N.
1927 Über die Turbellarien-fauna des Aralsees. Zool. Jahrb. Abt. Syst. Ökol. u. Geogr. Tiere. **54** (1/2): 98.

BRESSLAU, E.
1933 Turbellaria. Kükenthal-Krumbach, Handb. d. Zool. **2** (1): 52–320.

DU PLESSIS, G.
1889 Note sur l'*Otoplana intermedia*. Zool. Anz. **12:** 339.

GRAFF, L. V.
1913 Das Tierreich. Turbellaria II. Rhabdocoelida. p. 439. R. Friedlander und Sohn. Berlin.

HOFSTEN, N. V.
1918 Anatomie, Histologie und systematische Stellung von *Otoplana intermedia* du Plessis. Zool. Bidrag fr. Uppsala **7:** 1–74.

JENSEN, O. A.
1878 Turbellaria ad Litora Norvegiae Occidentalia. Turbellarier ved norges Vestkyst. Bergen. J. W. Eides Bogtrykkeri.

MARISTO, LAURI
1938 Beiträge zur Kenntnis der Monocelidinen (Turbellaria, Alloeocoela) Annales Zool. Soc. Zool.-Bot. Fenn. Vanamo **6** (3): 1–68.

MIDELBURG, A.
1908 Zur Kenntnis der Monocelididae. Z. f. wiss. Zool. **89:** 81.

SCHMIDT, O.
1857 Zur Kenntniss der Turbellaria rhabdocoela und einiger anderen Würmer des Mittelmeeres. Akad. der Wiss. zu Wien **23**: 347-368.

EXPLANATION OF PLATES 2 AND 3

Figure 1. Ventral aspect of specimen. Based upon living specimens and serial sections. *b*, "bursa seminalis"; *co*, male copulatory organ or penis; *dp*, dermal papilla; *en*, enteron; *fgp*, female gonopore; *g*, germarium or ovary; *mgp*, male gonopore; *od*, oviduct; *ph*, pharynx; *s*, posterior "spur" of body; *st*, statocyst; *t*, follicle of testis; and *v*, vitellarium. × 60.

Figure 2. Packet of rhabdites from posterior region of body. × 2000.

Figure 3. Reconstruction of posterior three-fifths of body as seen from left side. Based upon serial sections. *b*, "bursa seminalis"; *co*, male copulatory organ or penis; *en*, enteron; *fgc*, female genital canal; *g*, left germarium or ovary; *lod*, left oviduct; *lv*, left vitellarium; *lvd*, left vitelloduct; *mgp*, male gonopore; *mphs*, mouth of pharyngeal sheath; *ng*, nidamental glands; *ph*, pharynx; *rs*, receptaculum seminis; and *t*, follicle of testis. × 120.

Figure 4. Transverse section of a ventral region of "body-wall." *c*, cilia; *cm*, circular muscle; *ds*, discharged secretion material; *ec*, epidermal cytoplasm, outer layer; *lm*, longitudinal muscle; *n*, epidermal nucleus; *sc*, secretion canal; and *t*, outline of a testicular follicle. × 1600.

Figure 5. Two cells from enteric epithelium. *ec*, general epithelial cell; and *gc*, enteric gland-cell. × 1600.

Figure 6. Male copulatory organ or penis as seen in a compressed animal. *dej*, ductus ejaculatorius; *ns*, needle-like spines; *s*, thorn-like spines; *vg*, vesicula granulorum, and *vs*, vesicula seminalis. × 1200.

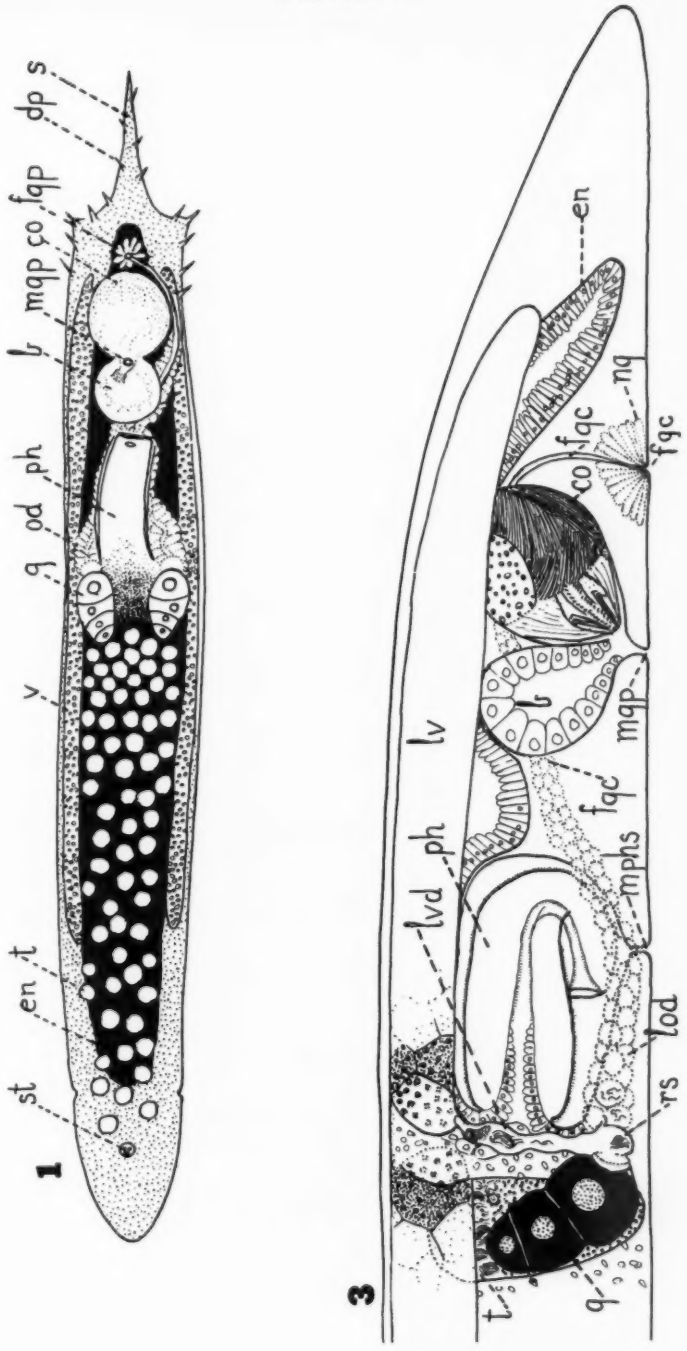
Figure 7. Male copulatory organ or penis and a section of wall of "bursa seminalis." Taken from a section. *b*, "bursa seminalis"; *epmga*, epithelium of male genital antrum; *m*, muscularis of "bursa"; *ns*, needle-like spines; and *s*, thorn-like spines. × 1200.

Figure 8. Extruded region of ductus ejaculatorius, with ejaculatory duct protruded. Taken from a compressed animal. *ns*, needle-like spines; and *s*, thorn-like spines. × 1200.

Figure 9. Spermatozoon. From a compressed vesicula seminalis. × 800.

Figure 10. Meiotic chromosomes. From an aceto-carmine preparation. × 800.

PLATE 2


1
st
en
t
v
g
od
ph
l
mgp
co
fgp
dp
s
3
en
ng
fgc
co
fgc
l
mgp
lv
lvd
ph
fgc
mphs
lod
rs
t
q

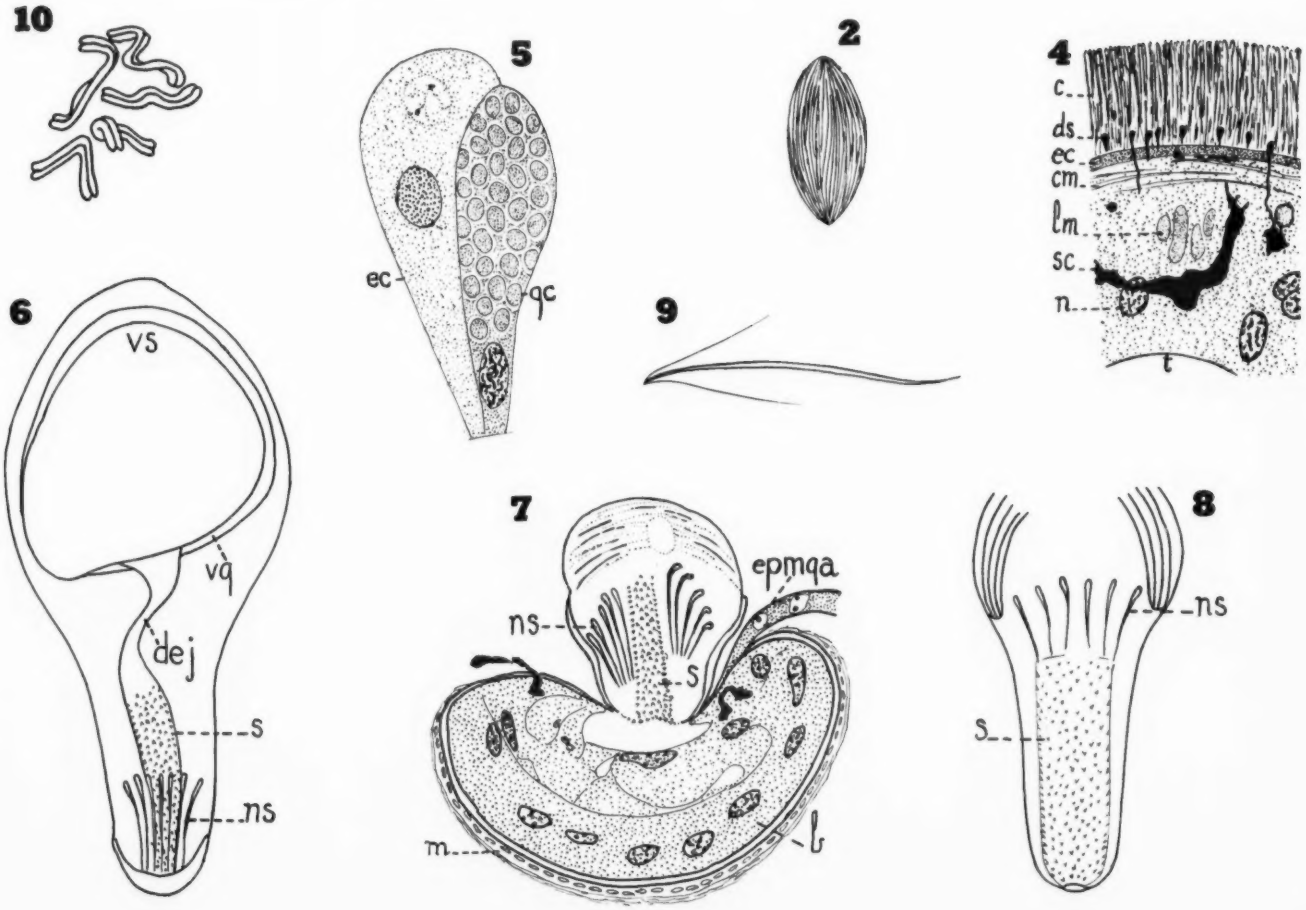


PLATE 3

A TWO-HEADED EMBRYO OF THE PIPEFISH, SYNGNATHUS FLORIDAE[1]

By L. E. Cable

Two Text Figures

Although the occurrence of bicephalous and double monsters apparently is not uncommon in certain species of fish observed in hatcheries and under laboratory conditions, records of such twinning in nature are comparatively rare. James F. Gemmill (1912) has gathered together much of the scattered literature on the subject of twinning in fishes. Of the numerous references listed by him, more than half deal with Salmonidae in the hatcheries. Of the other records, a few are doubtful, several concern abnormalities obtained experimentally, and eleven describe embryos from viviparous fishes. Of the latter type is the two-headed embryo of the spiny dogfish reported by Bond and Marchand (1929) as are also the two bi-truncate larvae of *Gambusia* described by Thirumalachar (1938). E. W. Gudger (1929 and 1938) described and figured some exceptionally large examples of two-headed trout reared in hatcheries.

Definite reference to twinning among oviviparous fishes in nature, however, are exceedingly rare. Only three records have come to my attention. The first, Churchill (1834), is of a Siamese gaff topsail catfish taken alive in a shrimp trawl at the mouth of the Cape Fear River, N. C., in August 1833. The individuals of this monster were $3\frac{1}{2}$ and $2\frac{1}{2}$ inches in total length and were connected by the skin of the breast. Both could swim in a nearly upright position, permitted by the length and pliancy of the connecting skin. The second record was made by Hugh M. Smith (1907) who, in referring to *Menticirrhus americanus* stated that "in Pamlico Sound during the winter of 1901–2, two kingfish each 7 inches long and laterally connected so as to constitute twins, were caught with hook and line by Joseph H. Kemp of Baltimore, Maryland." The third record was obtained by Dr. Gudger who writes (1929) that "in four or five years hatching of thousands of eggs of the toadfish, *Opsanus tau*, I did not find a single double head. Further,

[1] Published by permission of the U. S. Commissioner of Fisheries.

in six years' work with the orally incubated eggs of the marine catfish, *Felichthys felis*, involving the study of hundreds of eggs, I found but three monsters—one having three eyes (the third formed of two fused eyes) and two Siamese twins."

On July 28, 1928, while the author was stationed at the U. S. Fisheries Biological Laboratory, Beaufort, North Carolina, several pipefish were taken off Gabriel's Marsh in an otter trawl. One, a male *Syngnathus floridae*[2] (Jordan and Gilbert), 8½ inches long, carried eggs with well developed embryos, but no larvae, in its marsupium. The eggs

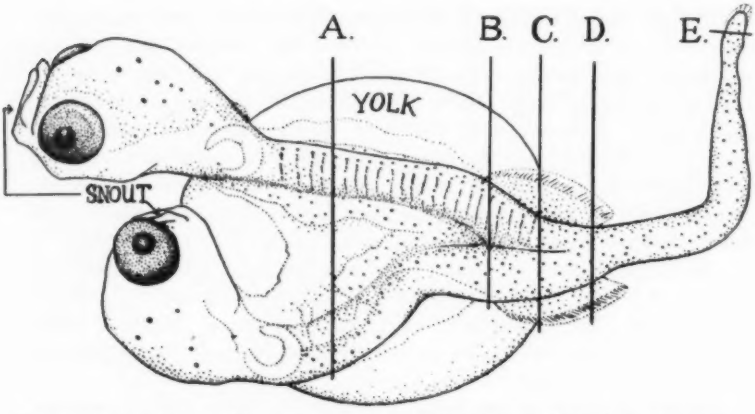


FIG. 1. *Syngnathus floridae*. TWO-HEADED EMBRYO WITH YOLK SAC ATTACHED. Lines A, B, C, D, and E indicate regions in which cross sections were taken. (See Fig. 2.)

Note: The tubular snout of the pipefish embryo is bent abruptly upward giving the mouth a vertical position. The maxillary at this stage in development is much longer in proportion to the length of the snout than that of the adult fish.

were so firmly attached to the inner wall of the brood pouch after preservation that it was difficult to remove them and in a number of cases the vitelline membrane was punctured or destroyed entirely during the process. Under the binocular microscope it was found that one of the embryos thus freed from the vitelline membrane had two

[2] See *Siphostoma floridae* Jordan and Gilbert. David Starr Jordan and Barton Warren Evermann, Bulletin, United States National Museum No. 47, Pt. I, 1896, p. 766; also David Starr Jordan, Barton Warren Evermann and Howard Walton Clark, Report of the Commissioner of Fisheries, Part II, 1928, Bureau of Fisheries Document No. 1055, p. 241.

well developed heads, and was double to near the anus (Fig. 1). At the point of union the two parts of the embryo faced each other. Posteriorly the body was single, having two dorsal fins of normal size and one small misshapen caudal fin. The caudal region was shorter and thicker than that of the normal embryos of the same brood, but there

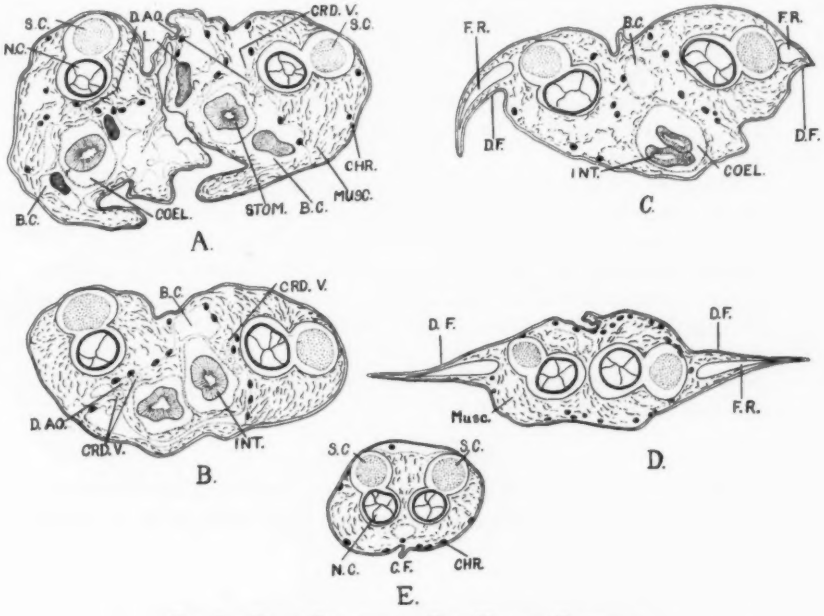


FIG. 2. CROSS SECTIONS OF TWO-HEADED PIPEFISH.

A. Section about two-thirds of the distance from the anus to the pectorals. B. Section in advance of the dorsal fins. C. Section through dorsal fins, anterior to anus. D. Section through dorsal fins, posterior to anus. E. Section near tip of tail. (See Fig. 1.)

B.C., body cavity; C.F., caudal fin; CHR., chromatophore; COEL., coelom; CRD. V., cardinal vein; D.AO., dorsal aorta; D.F., dorsal fin; F.R., fin ray; INT., intestine; MUSC., muscles; N.C., notochord; S.C., spinal chord; STOM., stomach.

was little difference in the size and development of the heads. The total length of this tiny monstrosity was approximately 8 mm.

First, to facilitate sectioning, the yolk material, which often becomes hard and brittle during fixation, was removed. The embryo was stained with alizarine and a complete series of cross sections made.

Five of these sections, reproduced in Fig. 2, show the presence of two spinal columns to the tip of the tail. They were twisted in such a way that although ventrally joined at the anus the embryos became laterally joined posteriorly (Sections D and E, Fig. 2). It will be seen from sections A, B and C, Fig. 2, that there was duplication of visceral organs. The intestines were united at the anus, however, and had a single anal opening. The intestine was straight, and there was no sharp demarcation between the intestine and the stomach, a condition normal to the species. The tissues surrounding the organs were abnormally developed to form several rather small, irregularly shaped body cavities instead of the usual smoothly rounded coelom containing all the organs.

Since the discovery of the twin just described, a careful examination of the eggs from dozens of other pipefish of this species has not revealed a single abnormality outwardly observable. Furthermore, in an unpublished communication Dr. Gudger advises that while studying the segmentation of the egg of this same fish he "literally examined hundreds of eggs but never found such an abnormality as the one herein described." It is probable, therefore, that the occurrence of double monsters among *Syngnathus floridae*, at least, is not common among the fish in their natural habitat.

ACKNOWLEDGEMENT

The author is indebted to Dr. E. W. Gudger for reading this manuscript, for his helpful advice and for unpublished information so kindly given.

U. S. BUREAU OF FISHERIES,
WASHINGTON, D. C.

LITERATURE CITED

BONDE, C. VON, AND J. MARCHAND
1929 A case of 'Siamese Twins' in the spiny dogfish (*Squalus fermandinus*). Nature **123:** 795.

CHURCHILL, SYL.
1834 Notice of a double fish. Amer. Journ. Sci. **26:** 116.

GEMMILL, JAMES F.
1912 The Teratology of Fishes. 73 pp., 26 pls. James Maclehose and Sons. Glasgow.

GUDGER, E. W.
1905 The breeding habits and segmentation of the egg of the pipefish, *Siphostoma floridae*. Proc. U. S. Nat. Mus. **39:** 483, pl. VI, fig. 26; pl. VIII, figs. 54, 55.

1910 Habits and life history of the toadfish (*Opsanus tau*). Bull. U. S. Bur. Fish. for 1908 (Proc. 4th Internat. Fish. Cong., Washington, 1908) **28:** 209.

1918 Oral gestation in the gaff-topsail catfish, *Felichthys felis*. Papers Dept. Marine Biol. Carnegie Instit. Washington, Pub. no. 252: pl. III, fig. 7.

1929 An unusually large (53 mm.) two-headed brook trout *Salmo fontinalis*. Amer. Mus. Novitates, no. 369, 10 pp., 2 figs.

1938 Ten two-headed trouts from 32 mm. to 203 mm. long—the record size. Journ. Elisha Mitch. Sci. Soc. **54:** 205–235, pls. 17–19 and 4 text figs.

SMITH, HUGH M.

1907 The fishes of North Carolina. N. C. Geol. and Econ. Survey. Vol. II, xi, 453 pp., 21 pls., 188 figs. Raleigh.

THIRUMALACHAR, B.

1938 On certain double monstrosities of *Gambusia*. Proc. Indian Acad. Sci., Sect. B, **7:** 317–322, 6 figs.

STRUCTURE AND DEVELOPMENT OF THE SEED OF CYNOGLOSSUM AMABILE STAPF & DRUMM.*

By Vera Millsaps

Plates 4–6

GENERAL INTRODUCTION

The external characters of the Boraginaceae have occupied the chief interest of students in the limited amount of work done upon the group up to the present time. The scorpioid inflorescence (28), the hairiness of the foliage (33, 42), the gynobasic style (6, 37), and the schizocarpous fruit (19, 37, 42) comprise the most characteristic features of the family and have received particular attention. Some emphasis has also been placed on the anatomy in studies that have been made of the root (5), the stem and leaves (15, 40), and the organogeny of the flower (18, 29).

The most extended work, however, done on the Boraginaceae has been the taxonomic studies by M. Gurke (11) for the whole family, by A. Brand (2) for the Cynoglosseae, a sub-division of the Boraginaceae-Boraginoideae, and by I. M. Johnston (16, 17) for a number of the genera of the Boraginaceae of North and South America.

The literature dealing with the morphological development of the family, or members of it, is scanty and fragmentary. Many of the writers who have made extensive studies of the embryo sac or ovule in various families have given only very condensed or partial accounts of the development of the ovule in the Boraginaceae (3, 9, 10, 13, 14, 31, 36, 38, 39, 41). The species, *Borago officinalis*, has served in the majority of cases as the type for study (3, 9, 13, 14, 21, 38). *Cynoglossum officinale* (3, 14, 23, 31) and *Pulmonaria officinalis* (13, 14, 24) are referred to next in frequency, but even less completely. Just recently, however, Svensson (35) has made a rather extensive investigation of the Boraginaceae in which he gives some morphological data, more or

* This is Part II of a thesis submitted to the Faculty of the University of North Carolina in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Botany. Part I was published in this Journal, **52**: 56–75. 1936.

less in detail, concerning the development of about eighteen genera with special emphasis upon the formation of the endosperm.

Cynoglossum amabile Stapf and Drummond, a representative of the Boraginaceae, has been selected as the type for this somewhat detailed study of the structure and the development of the seed. This species occurs in the mountain meadows of eastern Asia in the regions of eastern Tibet, Szechwan, and Yunnan (2). Here "bedeckt die Art die Ebenen in solchen Mengen, dass diese zur Blutenzeit den Anblick blauen Seen gewahren" (2). It is cultivated in the gardens of China, and has recently been introduced into this country from China for ornamental use.

MATERIAL AND METHODS

The material of *Cynoglossum amabile* upon which the present work is based was collected from the garden of Dr. W. C. Coker in Chapel Hill, North Carolina, during the summers of 1933 and 1934. Some of the material was killed in medium chromo-acetic solution and also in formalin acetic alcohol, but most of it was treated with Carnoy's fluid for two to three hours then transferred to Nawaschin's fluid for twenty-four hours. The rough coarse texture of the tissue around the buds, and particularly about the developing seed, required the use of Carnoy's fluid to get satisfactory fixation.

Considerable difficulty was experienced in getting the tissues sufficiently infiltrated with paraffin to cut. The ethyl-n-butyl alcohol series gave fair results with young material (43). The ethyl alcohol-ether series gave better results for the dehydration and infiltration of older material so its use was adopted for all stages for the greater part of the work.

Haidenhain's iron-alum haematoxylin, crystal violet and safranin, and Flemming's triple stains were used. The best results were obtained with Flemming's triple stain or with safranin and gentian violet alone.

THE MICROSPORANGIUM

The stamens arise according to the usual acropetal succession of floral parts. At first they have no connection with the corolla and alternate with the petals. Later when the corolla has become gamopetalous the stamens are inserted on the tube of the corolla by very short filaments. This is, according to Payer (29), a fairly general rule among gamopetalous plants.

The anther, almost immediately upon its appearance, becomes a

thick, elongated mass of meristematic cells surrounded by an epidermis. Very soon a cross section of it appears faintly four-lobed, and a few hypodermal cells in each lobe show by their slightly increased size and radial elongation that they are to function as archesporial cells. Periclinal division follows in these cells, thus cutting off a primary parietal layer and forming an inner sporogenous layer which is easily identified by its deeper staining properties (Fig. 1).

The primary parietal layer divides by periclinal walls forming an inner layer which later becomes part of the tapetum and an outer layer which divides once again periclinally (Figs. 3, 4). There are, then, three parietal layers formed within the epidermis. Anticlinal walls occur to extend these layers as the enlarging anther requires. The outermost layer becomes the endothecium. Its cells increase in size and their contents stain more darkly than the surrounding cells as the anther approaches maturity. The cell walls thicken considerably, especially on the inner ends and sides (Fig. 10). The wall of the mature anther consists of two layers, the endothecium and the outer epidermis (Fig. 10). There is no particular stomium formed, but a thin place between the two locules in each half of the anther develops and serves as a point of dehiscence (Fig. 11).

The cells of the middle parietal layer soon become flattened out and disorganized, and almost, if not entirely, disappear by the time that the spore tetrads form (Fig. 8).

The innermost, or third, parietal layer becomes a part of the tapetum and serves to nourish the developing sporogenous cells within. The remainder of the tapetum is developed from the first row of meristematic cells adjoining the sporogenous tissue. The tapetal cells attain their greatest development during the formation of the tetrads. The cells are more or less rectangular in shape, stain darkly, are considerably vacuolated, and contain only one nucleus (Fig. 8).

It is the common rule for the tapetum to be uninucleate in the Cynoglosseae although most of the Boraginaceae have multinucleate tapetal cells. Svensson (35) found three or four nuclei in the tapetal cells of *Lycopsis arvensis* and *Echium plantagineum*, and a low number in all other species examined, usually never more than three or four, except in *Anchusa sempervirens* which sometimes has as many as ten.

By the time that the tetrad cells are well formed the middle parietal layer has practically disappeared and the tapetal cells show signs of the disorganization which is common for the tapetum of angiosperms (20). The nuclei disintegrate and the cytoplasm seems to be absorbed

almost entirely from the cells even before their walls collapse, thus leaving a sort of transparent ring for a time between the spore chamber and the endothecium (Fig. 9). Later the cells do collapse and completely disappear. During this time also the walls of the outermost parietal layer begin to develop the thickenings characteristic of the mature endothecium.

The primary sporogenous cells divide rapidly in all directions during the development of the parietal layers so that a more or less round column of sporogenous tissue comes to extend throughout the length of the anther in each of the four lobes (Fig. 3).

The spore mother cells increase considerably in size and stain more readily than the tapetal cells at this stage (Fig. 6). They do not round up and become isolated, but remain in contact with each other in the sporangium until after the formation of the tetrads (Figs. 7, 8).

The anther wall attains its two-layered mature stage and encloses free microspores by the time that the ovule reaches the megaspore stage.

THE MALE GAMETOPHYTE

The first reduction division of the spore mother cell, which initiates the gametophyte stage, occurs about the time that the tapetal cells reach their maximum size and the middle parietal layer has largely disappeared (Fig. 7). The second division follows immediately (Fig. 8). All the cells in a microsporangium seem to pass through these stages simultaneously as cases were observed where every spore mother cell in a cross section of a microsporangium was in the same stage of division (Figs. 7, 8).

The mother cells making up the mass of the sporangium break apart after the formation of the tetrads and the young microspores are soon freed by the prompt disappearance of the mother cell wall.

The mature pollen grain of *Cynoglossum amabile* is very small. Fresh spores measure 6–8 μ by 10–12 μ. Mohl (26) in his extended study of the form and structure of pollen grains in a large number of families disposed of those of the genus *Cynoglossum* by saying that they were too small to allow any precise observation. The grains have a smooth wall and are constricted somewhat in the mid-region giving in outline the form of a figure 8 similar to that of the pollen grain of *Myosotis*. According to Gueguen (7) an elongated form is characteristic of the pollen grains of all the sub-family Boraginoidae. Following his classification, there are two types of pollen, elongated and round. He saw here a nice relation between the spaces of the papillae on the stigmatic

surface of the type including *Cynoglossum* and the shape of the pollen grains in that their elongated form with the constricted mid-region enabled them to lodge readily between the adjoining papillae.

The points of exit for the pollen tubes lie in the constricted mid-region. According to Schacht (32) there are three points of exit for the pollen tubes in the Boraginaceae. This number has been quoted by subsequent writers such as Goebel (6) and Coulter and Chamberlain (4). However, Svensson (35), in a more recent study, says that the Boraginaceae have two pollen tube exits. Only two were observed in this study of *Cynoglossum amabile*.

The chromosome number could only be approximated from late anaphase stages of the first reduction division of the spore mother-cell as being possibly 13–15 for the haploid number (Fig. 14). Svensson (35) undertook the chromosome count in only one species, *Lycopsis arvensis*, in which he estimated that there are perhaps 27 haploid chromosomes. He also quoted Winge as having estimated 18–20 as the possible number of chromosomes in *Myosotis micrantha*.

The Boraginaceae comprise one of the groups of Dicotyledons which have three-nucleate pollen grains. The division of the generative nucleus takes place before the germination of the pollen tube (34). Halsted (12) reported the presence of three nuclei in the pollen grain of *Sambucus racemosa* in 1887 and stated then that he knew of no similar record in the literature. Strasburger (4), however, had announced the presence of three-nucleate pollen grains in a number of genera among Dicotyledons three years earlier. Schurhoff (34) considers the three-nucleate state of pollen grains a character of systematic significance and thinks that it indicates a progressive developmental tendency.

In the fully mature grain the tube nucleus which is subspherical is usually found in or near the constricted center of the grain, the slightly smaller and more oval sperm nuclei occupying the two ends, though at times both may be seen in the same end (Figs. 18, 19, 20).

THE MEGASPORANGIUM

The Boraginaceae are especially characterized by the nature of their ovary and by the style which is gynobasic. The ovary is in reality bilocular though in the mature form it appears to be quadrilocular. So many changes take place during the development of the fruit that it seems well to follow them briefly in order to understand the origin, location, and subsequent behavior of the ovule in the ovary.

Payer's excellent work, *Traité D'Organogénie Comparée de la Fleur*, and the papers of Chatin (3), Guignard (8), Van Tieghem (37), and Joxe (19) give descriptions more or less in detail concerning the morphology of the pistil of the Boraginaceae. It arises from two semilunar pads of tissue which touch end to end. As these structures grow upward they form an enclosure and the lines of fusion between them give two thick ridges which are the rudiments of the placentas. These are extended at their base in such a way as to divide the cavity into two chambers (29). The ovules, two in each chamber, are borne on these extended portions of the placentas. As growth proceeds the carpellary walls extend upward more and more, thus forming a continuous enclosure until a deep sac results. This gradually draws together at its summit until a sort of flask-like body is formed, the lower part of which is the ovary and the upper part the style. In the meantime, on the interior, the two placental cords, which are parietal, have grown toward each other, fused, and thus divide the upper part of the ovary into two parts which are continuous with the two parts already formed in the lower region where the ovules arise (29).

Due to inequalities in growth the ovary becomes quadrilocular (1, 29). The lower and outer sides of each carpel grow out considerably thus leaving the mid-part of the outer wall containing the median nerve at the bottom of a deep fold. The inner part of this fold extends in as a sort of false partition and becomes concrescent with the central region thus forming two compartments in each carpel (37). Thus the ovary which was at first bilocular becomes quadrilocular.

The pistil of *Cynoglossum amabile* develops according to the above manner and has the so-called gynobasic style. The ovule is attached on the dorsal face of the carpellary border and is supported by a long funiculus which winds in between this border and the median nerve. The funiculus enters the ovulary compartment at its upper end and is directed laterally (19, 37).

Each ovary may contain four ovules, two in each carpel, though there is some tendency toward abortion. One to all four ovules may fail to develop. This tendency to ovule-reduction is considered as a characteristic of advanced development (42). One case of pleiomery was also observed in which there were six ovules, thus indicating a three-foliate origin of the ovary (Fig. 30). Svensson (35) found examples of this in *Lindelofia longiflora* and *Cynoglossum officinale*.

The ovule is anatropous but in the reverse order. The curvature takes place in such a way that when it is complete the micropyle is

turned toward the style and placenta, the chalazal region toward the bottom of the compartment, and the side to which the funiculus is attached faces the similar part of the companion ovule in the same carpel (3, 29, 37). The embryo then has its radicle directed upward and toward the style in the mature seed (3).

Soon after the four compartments are formed in the ovary, a slight protuberance arises toward the base of the placenta in each compartment. This tubercle is formed of a mass of little cells and constitutes the nucellus of the developing ovule (3). A single integument arises near the base of this tubercle, grows rapidly up around it toward its free end, and finally closes in over it, leaving only a narrow micropylar opening. The nucellus rarely projects much beyond the micropyle, and then only for a short time before the integument overgrows it (3).

The integument arises through periclinal division in the epidermis. This stage and origin of the integument has also been observed by Svensson (35) in *Lycopsis arvensis*, *Borago officinalis*, and *Cynoglossum officinale*. It is characteristic of the Boraginaceae, and particularly of *Borago officinalis*, according to Chatin (3), for the integument to grow up over the nucellus rather slowly. However, it was his observation that the growth in *Cynoglossum officinale* is more rapid. Svensson (35) reports that the growth in the entire group is rapid as the nucellus is completely enclosed by the integument when meiosis occurs in the megaspore. This is the case in *Cynoglossum amabile*. One megaspore mother cell was seen in which the nucleus was in synapsis in preparation for the first division after the nucellus was already deeply covered over by the integument (Fig. 22).

The integument is proportionally thick and massive. This fact was also emphasized by Hofmeister (14) and Guignard (8, 10). While it is attaining its development the whole ovule effects its anatropous position in the remarkable manner characteristic of the Boraginaceae by directing its curvilinear movement toward the summit of the carpellary chamber so that the micropyle is turned toward the side of the style (Fig. 27). In the meantime the carpellary disc enlarges so as to form a sort of plateau from which the ovule is separated only by a very thin wall.

The nucellar mass of cells in *Cynoglossum amabile* is small in comparison with the massive integument (Fig. 21). In longitudinal section it usually shows three rows of cells, sometimes two, surrounded by an outer layer, or epidermis. The hypodermal cell in the middle axial row becomes the megaspore mother cell directly without the formation

of any parietal cell. This behavior has also been observed in *Lycopsis arvensis, Borago officinalis, Pulmonaria officinalis, Cynoglossum officinale* (35), *Symphytum orientale* (41), and *Trachystemon orientale* (40). A few sections were seen in which the mother cell was slightly differentiated in size more than by its staining properties before the integument had closed up around the nucellus completely (Fig. 21). The mother cell shown in Figure 22 in the stage just preliminary to reduction has so increased in size as to have destroyed all but the outer layer of the nucellus.

The integument is also well supplied with fibrovascular strands. Branches from the vascular strands leading to the corolla pass up through the disc and the funiculi to each of the four ovules (Fig. 39). A vascular strand on reaching an ovule sends out five to seven branches which run out superficially directly under the epidermis of the integument (Figs. 40, 44). This tissue is easily identified in sections with safranin and gentian violet as it stains much less than the surrounding tissue and the cells are smaller and elongated. Guignard (10) had much earlier observed these strands in *Borago*. Svensson (35) found that such vascular strands were weakly formed in *Echium* and *Lycopsis*, but that they were particularly well developed and copiously branched in *Borago, Symphytum, Nonnea, Cerinthe*, and the Cynoglosseae.

There is never any integument tapetum developed. The tissue of the integument lying at first next to the nucellus then later in contact with the embryo sac, consists, especially on the ventral side of the ovule, though all around to some extent, of large irregular cells. The outer region of the integument consists of smaller, more compactly arranged cells which stain darkly, indicating a rich cell content. The cells of the inner region become very irregular in arrangement, collapse to some extent, and stain lightly with safranin and gentian violet, thus indicating a poverty of cell contents (Fig. 36). The developing embryo sac draws its sustenance from the surrounding region. This whole inner region including a narrow streak to the outer margin following the path of the micropyle stains less than the remaining tissue of the integument. There is, however, no sharp line of division between an outer and internal zone as Guignard (10) emphasized for *Borago officinalis*.

Cynoglossum amabile also shows the interesting external conformation in the integument reported for other species of *Cynoglossum* and for *Myosotis* (35). There is a rostrum-like projection at the micropylar exit which extends toward the base of the style (Fig. 51). This struc-

ture apparently aids in shortening the distance for the pollen tube in passing from the conducting tissue of the style to the ovule.

THE FEMALE GAMETOPHYTE

The megaspore mother cell in *Cynoglossum amabile* usually forms four megaspores. However, they do not seem to conform to the usual axial row. Figure 26 shows an arrangement frequently observed. It appears that the first division in the mother cell was periclinal, followed by a second periclinal division in the lower daughter cell and an anticlinal division in the upper daughter cell. Such a condition has been observed in *Butomus*, *Jeffersonia*, and *Potamogeton* (4). The lower cell has a large nucleus and is much larger in size than the others, which indicates that it will be the functional megaspore. The nuclei in the other three megaspores have practically disappeared and the cells are in the early stages of disintegration. The small cells adjoining the megaspores in this figure are the scattered remnants of the one-layered nucellus which is absorbed very early in the development of the embryo sac.

Figure 25 shows a similar condition except that the second division of the lower daughter cell appears to have been oblique rather than periclinal. The two upper megaspores, evidently formed by anticlinal division, are considerably advanced in the stage of disintegration, while the third is only slightly smaller than the fourth. Mottier (27) has also reported instances of oblique walls in the formation of megaspores.

Occasional sections also indicate that sometimes only three cells are formed. Figure 23 shows a case where the lower daughter cell has not divided. Its size and well developed nucleus indicate that it is the forerunner of the embryo sac. The upper daughter cell has divided anticlinally to form the upper megaspores whose nuclei already show signs of disintegration. Figure 24 shows that at times the upper daughter cell may not divide, while the lower daughter cell divides anticlinally. One of the lower cells is already slightly larger than the other and will be the functional megaspore.

Svensson (35) observed macrospore tetrads in ten genera of the Boraginaceae in which the macrospores were usually in a longitudinal row. These genera were as follows: *Symphytum officinale*, *Pulmonaria officinale*, *Nonnea lutea*, *Borago officinalis*, *Lithospermum officinale*, *Lappula echinata*, *Myosotis arvensis*, *Asperugo procumbens*, *Cerinthe major*, and *Cynoglossum officinale*. However, he reports having seen one so-called T-tetrad in *Cynoglossum officinale* and frequent instances where the upper diad in this species remained undivided.

Vesque (39) reported the formation of macrospore tetrads in *Trachystemon orientale.*

The degeneration of the upper megaspores takes place rapidly. Numerous instances were seen in *Cynoglossum amabile* where the upper cells were definitely beginning to disintegrate though no mere remnants of them were seen. The last stages of absorption evidently go on very rapidly.

Svensson found that the 8-nucleate embryo sac developed from the chalazal megaspore cell in the majority of the Boraginaceae which he investigated, or from the chalazal diad cell as in *Lycopsis* and *Anchusa.* Few writers have given more than scattered accounts of its development. Guignard (8), however, gave a very brief account of the embryo sac in *Borago officinalis* which accords with Svensson's recent findings. Hofmeister (14), Rosanoff (31), and Vesque (38, 39) made brief references to the embryo sac in the Boraginaceae, but did not follow the development completely.

The 8-nucleate sac in *Cynoglossum amabile* develops in the usual manner from the lower megaspore. This cell elongates, its nucleus divides and between the resulting two a large vacuole develops (Fig. 31). Figure 32 shows a sac with three nuclei, the fourth chalazal nucleus having been cut off in an adjoining section. Figure 33 shows an early 8-nucleate stage and Figure 34 shows a sac after the egg apparatus has been organized and the chalazal nuclei have become marked out as antipodal cells in the lower end of the sac.

By the time that the 8-nucleate stage is reached all of the nucellus and upper megaspores have disappeared and the surrounding cells of the integument show signs of disintegration and collapse due to the absorption of their cell contents by the developing embryo sac. Within the sac the cytoplasm is more dense in the micropylar end where the egg apparatus is formed. The egg assumes the usual appearance though it is perhaps a little less tapered toward the micropylar end. It extends only slightly farther into the sac than the synergids. It is usually vacuolate in the upper end, stains deeply, and has a nucleus toward the lower end which is slightly larger than those in the synergids (Fig. 34). Svensson found the egg nucleus to be larger also in *Borago officinalis, Myosotis arvensis,* and *Cynoglossum officinale,* and smaller in *Echium creticum, Lycopsis arvensis,* and *Nonnea lutea.*

The synergids have a rounded, blunt form, are rarely vacuolated, have rather inconspicuous nuclei, and stain only a little less deeply than the egg. One synergid is destroyed by the entrance of the pollen tube while the other remains fairly intact for a short time (Fig. 35).

One synergid remains in good condition for such a long time in *Lycopsis arvensis* and *Nonnea lutea* that Svensson concluded that it must have a post-fertilization nutritive function for the embryo in these genera.

The upper polar nucleus remains in the cytoplasm near the egg apparatus while the lower polar nucleus moves up beside it very soon after their formation. The polar nuclei are larger than the other nuclei almost from the beginning, appear decidedly oval, have very large nucleoli, and do not fuse before fertilization. This retarded fusion of the polars was so general among the types of the Boraginaceae investigated by Svensson that he considered this behavior a general characteristic of the family and in this respect different from other Tubiflorae.

Three antipodal cells are formed by lines of cleavage in the cytoplasm about the antipodal nuclei in the lower part of the sac (Fig. 34). They do not seem to have any definite arrangement, and are very transitory in nature, disappearing entirely before fertilization.

There are from one to three antipodal cells in most of the Boraginaceae according to Svensson (35). He observed three, small, ephemeral cells in the following: *Borago officinalis*, *Lithospermum officinale*, *Cerinthe major*, *Myosotis arvensis*, *Lindelofia longiflora*, and *Cynoglossum officinale*. References in the literature include some contradictory data on the antipodals, probably due to their transitory nature and to the fact that lateral endosperm nuclei were mistaken for them in some instances. Hofmeister (14) reported no antipodals in *Borago*, *Pulmonaria*, and *Cynoglossum*. Guignard (8) observed three small ones in *Borago officinalis*. Rosanoff (31) and Lotscher (25) reported large antipodals in a number of species which Svensson (35), in more recent and detailed studies, has shown to have small and transitory ones or none. They have instead some large lateral endosperm cells which might easily be mistaken for antipodals.

The shape of the 8-nucleate embryo sac at the time of its formation is a long oval, but by the time of ferilization, the sac is strongly dilated in its micropylar half and terminates very abruptly at the chalazal end largely because the antipodal cells have disappeared (Figs. 34, 37). The chalazal region broadens somewhat during the later development of the endosperm so that the width of the sac comes to be more nearly the same throughout its entire length (Fig. 42). The embryo sacs in the whole group of the Cynoglosseae follow this general conformation while those of the Anchuseae are characterized by a conspicuous lateral diverticulum (35).

FERTILIZATION

In numerous cases pollen tubes were found in the micropyles and reaching the embryo sac (Fig. 35). In one case observed there were evidently two tubes in the same micropyle (Fig. 36). Svensson (35) found pollen tubes in the micropyles in *Symphytum officinale, Lappula echinata, Echium plantagineum,* and *Lindelofia longiflora.* The number of genera in which this has been observed is sufficient to indicate that porogamy is characteristic for the Boraginaceae. The integument rostrum in *Cynoglossum* is evidently advantageous to the tube in passing from the conducting tissue of the style to the micropyle (Fig. 51).

Double fertilization occurs in *Cynoglossum amabile.* Figure 36 shows the micropylar region of an embryo sac in which a sperm nucleus is in contact with the nucleus of one of the polars. It appears slightly oval in shape. The other sperm is lying near the nucleus of the egg. Figure 37 shows one sperm nucleus within the mass of cytoplasm containing the two nucleoli of the polars indicating that fusion of all three was in progress. The other sperm nucleus is shown in the act of passing over the intact synergid on its way toward the egg nucleus. Sperm nuclei within eggs were observed repeatedly (Fig. 35).

The only actual case of double fertilization in the Boraginaceae found in the literature is that of *Lappula echinata* in which Svensson (35) observed a small sperm by one of the polars and one close by the egg nucleus. He also saw a sperm near a polar nucleus in *Lithospermum officinale,* and one close by an egg in *Myosotis arvensis.*

The endosperm nucleus sometimes shows three nucleoli, thus indicating its recent fusion and triple origin. A stage following soon after fertilization is shown in Figure 38. The fertilized egg contains a large nucleus and conspicuous nucleolus and the fusion nucleus is entering the spireme stage in preparation for the formation of the first endosperm nuclear division.

THE ENDOSPERM

The division of the fusion nucleus begins the formation of free endosperm nuclei which become scattered around in the parietal protoplasm of the embryo sac. After a number of such nuclei have been formed they begin to aggregate about the young embryo more than about the walls though they occur still as free nuclei embedded in the cytoplasm (Fig. 41). There are already several free nuclei formed by the time that the embryo has become 2-celled. In one sac containing a 4-celled embryo thirty-six free nuclei were counted. The nuclei which crowd around the embryo are slightly larger than the others and soon begin

to be separated from each other by cell walls (Fig. 43). Gradually wall formation between the nuclei extends around the wall of the embryo sac also. Any nuclei within the first row of endosperm cells around the wall may remain free for some time. Web-like strands of protoplasm, however, soon extend about the remaining nuclei enclosing them within large cells (Fig. 46). Their nuclei, often containing two or three nucleoli, divide another time or two with walls forming between so that the sac comes to be lined with a layer of endosperm, rarely more than two or three cells thick, except at the upper micropylar end which becomes filled up with cells (Figs. 45, 46).

The inner part of the embryo sac is never completely filled with endosperm, but it contains a plasma fluid which is gradually displaced by the rapidly growing embryo. Such a fluid is common among the Boraginaceae. *Borago officinalis* has been frequently cited as having an unusual abundance of this sac fluid (3, 10). M. Robin (30) made the statement in 1848 that such a fluid might be regarded as being analogous to the *vitellus*, the embryo sac representing the egg of plants and its wall playing the rôle of a vitelline membrane. *Cynoglossum officinale* likewise contains an abundance of such a fluid until the embryo fills up the sac (3).

Short and fragmentary references have been made in the literature regarding endosperm formation in the Boraginaceae. Hofmeister (14) reported that free nucleate endosperm was found in *Pulmonaria*, *Borago*, and *Cynoglossum*, and that in the last named the nuclei tended to aggregate about the micropylar end where cell formation later began. Rosanoff (31) reported the same observation for *Cynoglossum* and *Omphalodes*. Hegelmaier (13), Guignard (10), and others reported that endosperm formation in the Boraginaceae is at first free nucleate, becoming cellular later.

Svensson (35) has recently made the most extensive study of this family yet done in which he paid particular attention to the method of endosperm formation. He attributes the statements of previous workers that endosperm formation in the Boraginaceae is free nucleate at first, becoming cellular later, as due to the fact that they happened to examine genera in which this is largely true. It was after the examination of a large number of genera that Svensson came to the conclusion that there are five general types among the Boraginaceae, ranging from the typical nuclear type through transition forms to the typical cellular type. These types as designated and characterized by him are as follows:

Borago-Type: Typical nuclear endosperm is formed.

Lycopsis-Type: Four free nuclei are first formed. A wall then appears cutting off two of these nuclei into a small lateral space and leaving the other two in the large central space. The lateral nuclei divide once more thus forming four nuclei; the two central nuclei behave as typical nuclear endosperm. Four stages are distinguishable: Free nuclear division followed by cell formation, then free nuclear division again followed by cell formation.

Echium-Type: The first division is followed by an oblique wall which divides the sac into a lateral and a central endosperm region. The lateral nucleus divides and a wall forms between them. No further cell walls form here though the nuclei may divide several times, thus giving two lateral multinucleate cells. The central region develops typical nuclear endosperm which later becomes cellular.

Lappula-Type: A longitudinal wall forms between the two nuclei resulting from the first division, but this wall extends only down to a big vacuole in the lower part of the sac. These two nuclei divide and another longitudinal wall forms at right angles to the first and extends down to the vacuole. The nuclei continue to divide further. Some wander down into the lower region where they divide repeatedly. The nuclei in the micropylar region divide rapidly and are cut off by cell walls in each case. Two types of endosperm formation are recognizable from the beginning, cellular endosperm in the micropylar end and free nucleate endosperm in the chalazal region.

Myosotis-Type: Typical cellular endosperm is formed from the beginning.

Svensson (35) is of the opinion that the Cynoglosseae belong to the *Lappula*-type because in the young stages of the species which he examined he found cellular endosperm in the micropylar end and free nuclei in the wall plasm lining the rest of the sac. Due to the fact that his data for this study were incomplete and also to the fact that Hofmeister (14) and others observed nuclei accumulated in the micropylar end in this group he admits the possibility that the Cynoglosseae may form free nuclei exclusively at first then later begin cell formation in the micropylar end of the sac. This supposition is in accord with our actual findings in *Cynoglossum amabile.*

THE EMBRYO

The egg remains in a resting stage for a time and does not divide until after a number of endosperm nuclei have been formed. The lines of division follow the usual order, though there seems to be a tendency for them to be slightly oblique rather than directly transverse

and perpendicular. As growth proceeds transverse division may at first exceed longitudinal division as shown in Figure 43. Walls appear in all directions so rapidly, however, that soon a globular mass of cells is formed (Fig. 45). The suspensor in *Cynoglossum amabile* is short and transitory. Sections from several 8-celled embryos showed one suspensor cell (Fig. 41). Figures 43 and 45 indicate that there may be as many as three suspensor cells. No embryo was seen with more than three while most of them had only one. The transitory nature of these cells is indicated by the early disintegration of the nuclei and cell contents. This condition is already visible in the last mentioned figures.

The suspensor is in general feebly developed in the Boraginaceae, ranging from none in *Borago* and *Lycopsis* to one large swollen cell in *Onosma* and others, or from a row of one to three or four cells in some to a fairly massive one in *Echium* (35).

The embryo continues to grow until all the endosperm tissue is used up in the embryo sac except one layer of cells around the margin (Figs. 47, 49). In the meantime it has become differentiated to form two massive and almost circular cotyledons and a short tapering radicle (Fig. 52).

THE SEED

The mature seed of *Cynoglossum amabile* consists of a large embryo comprising the main bulk of the seed, one layer of endosperm cells, and several layers of integument cells which consist of little more than the collapsed, or almost collapsed, cell walls enclosed by an epidermis (Figs. 48, 49). Remnants of endosperm cells within the outer layer may be seen in sections of the maturing seed. Figure 48 shows the integument cells somewhat pulled away from the endosperm and illustrates how the cell walls collapse after the loss of their contents.

Guignard (10) found one layer of endosperm in *Borago officinalis* and a formation of the seed coat similar to that observed in *Cynoglossum amabile*. Chatin (3) indicated the presence of several layers of endosperm in the ovule of *Cynoglossum officinale*, but he most probably studied a section from an immature seed.

A mature seed shows the attachment point of the funiculus from which region five to seven procambial strands branch out over the seed coat (Figs. 39, 40, 53). Sections of ovules reveal the fact that spiral vessels sometimes accompany these ramifications (Figs. 50, 51). Le Monnier (22) found a similar arrangement in *Cynoglossum pictum* and *Lithospermum*.

A longitudinal section of the embryo through the narrow plane shows that its tissues are distinctly differentiated (Fig. 54). The cells of the root cap, growing point, and epidermis are clearly defined (Figs. 54, 55, 56, 57, 58). The size of the epidermal cells tends to become smaller in the upper region of the cotyledons. Procambial strands extend from the hypocotyl up into the cotyledons.

The position of the seed in the ovary is such that the radicle is pointed toward the style and lies within the tapered point of the nutlet, or matured quadrilocular section of the ovary which is termed a mericarp (6). The seed is never shed from the ovary coat which serves as a protective covering and also as a means of dissemination since its upper surface is strongly echinate (Fig. 63).

The ovary wall consists of three layers. At the time when the ovule contains a mature embryo sac it consists merely of a rim of large undifferentiated cells covered by an inner and outer epidermis of somewhat rectangular cells (Fig. 59). As the ovule grows all layers begin to change. The outer epidermal cells elongate considerably and very unequally so that the surface of the ovary becomes uneven, the cells of the middle region enlarge, and the walls of the inner layer thicken somewhat (Fig. 60). The inner and lateral walls of the inner epidermis continue to thicken, the width of the side walls tapering from the inside outward, until most of the cell contents are used up (Fig. 62). These walls are completely lignified in the mature ovary. When viewed from the inner surface they appear as in Figure 64.

The outer epidermis particularly on the outer edge and upper surface develops numerous tapering columnar elevations, the terminal cells of which end in strong incurving spines. The lateral cells have low elevations on the outer surface bearing little spiny projections (Fig. 63). Thickenings follow along the cell walls and frequently extend in a netted arrangement over the wall surface (Fig. 61). The whole outer epidermal layer becomes very hard and more or less calcified.

At the point where the nutlet breaks away from the carpellary disc there is a little scar where the tissue is very thin. The radicle lies just within so it is at this point it pushes through when the embryo begins to germinate.

SUMMARY

1. The stamens of *Cynoglossum amabile* arise in the usual acropetal order and become epipetalous.

2. The young anther wall has three parietal layers within the epidermis formed from the primary parietal layer. The innermost layer

forms part of the tapetum, the middle layer disappears during the development of the spores, and the outermost becomes the endothecium and persists in the mature anther.

3. The tapetal cells are rectangular in shape and uninucleate. They disappear entirely after the formation of the tetrads.

4. The spore mother cells do not round up and become isolated, but remain in contact until after the formation of the tetrads.

5. In any one sporangium the tetrads are formed simultaneously.

6. The mature pollen grains are 6–8 μ by 10–12 μ in size and somewhat constricted in the mid-region, where the pollen-tube exits are found.

7. The haploid chromosome number is approximately 13–15.

8. The mature pollen grain is three-nucleate. The sperm nuclei are slightly smaller than the tube nucleus, and are elongate-oval in shape.

9. The ovary is bilocular, becoming quadrilocular at maturity, and the style is gynobasic.

10. The ovules are anatropous in the inverse order characteristic of the Boraginaceae, that is, the micropyle is turned toward the style instead of toward the basal disc.

11. A single massive integument grows up rather quickly around the small slender nucellus.

12. The integument is supplied with 5–7 fibrovascular strands branching out over the surface of the ovule and later over the seed coat.

13. The integument has a rostrum-like projection about the micropylar exit.

14. The nucellus disappears very early.

15. There is no integument tapetum. The cells of the inner region of the integument are gradually displaced and absorbed by the developing embryo.

16. The megaspore mother cell is formed at once from a single hypodermal cell. The growth of the integument over the nucellus embeds this cell deep within the ovule.

17. The formation of the megaspore is variable. Four megaspores are usually formed by a periclinal or an oblique division in the lower diad and an anticlinal division in the upper diad. Only three cells may be formed. Either the upper or lower diad may divide anticlinally while the other remains undivided, but in either case the embryo sac develops from a lower cell.

18. The 8-nucleate sac develops in the usual manner. The egg

nucleus is slightly larger than the synergid nuclei and is located in the lower end of the egg. The synergids have a rounded blunt form, are rarely vacuolated, and have rather inconspicuous nuclei.

19. The polar nuclei are larger and have conspicuous nucleoli. The upper polar remains near the egg apparatus and the lower polar moves up by it very soon. These do not fuse until after fertilization.

20. There are three small antipodal cells which disappear before fertilization.

21. The embryo sac is a slender oval in shape at the time of becoming 8-nucleate, but becomes strongly dilated at the micropylar end by the time of fertilization. Later during endosperm development the width of the sac becomes nearly equal throughout.

22. Double fertilization was observed.

23. Endosperm formation is at first free-nucleate then cellular. Nuclei aggregate about the embro where cell formation begins and later proceeds around the wall of the sac. The endosperm layer around the sac never becomes more than two or three cells thick, though the upper micropylar end becomes cellular throughout.

24. The entire embryo sac is never filled with endosperm, but contains a fluid which comes to be displaced by the maturing embryo.

25. The embryo, following the usual order of cell division, develops very rapidly. It has a one- to three-celled suspensor which disappears very early. The mature embryo has two massive and almost circular cotyledons at the base of which there is a short tapering radicle. The cells of the root cap, growing point, and epidermis are clearly defined.

26. The mature seed consists of a large embryo, one layer of endosperm cells, and several layers of integument cells, consisting largely of collapsed cell walls enclosed by an epidermis.

27. The ovary wall consists of three layers: (1) an inner epidermis whose inner and lateral walls become thickened and lignified; (2) a middle layer of large, irregular parenchyma cells; (3) an outer epidermis whose cells are radially elongated throughout the entire surface and at intervals form projections with strong incurving spines. These aid in the dissemination of the seed which is never shed from the quadrant portion of the ovary.

LITERATURE CITED

1. BONNIER, G., AND L. SABLON
1901 Cours Botanique. J. Poinsot & A. Millot. Paris.
2. BRAND, A.
1921 Borraginaceae-Borraginoideae, Cynoglosseae. Das Pflanzenreich **4**, No. 252.

3. CHATIN, M. J.
1874 Études sur le développement de l'ovule et de la graine, etc. Ann. Sci. Nat. Bot. ser. 5, **19:** 5–107.
4. COULTER, J. M., AND C. J. CHAMBERLAIN
1904 Morphology of Angiosperms. D. Appleton and Co. New York.
5. FLAHAULT, CH.
1878 L'accroissement terminal de la racine chez les phanérogames. Ann. Sci. Nat. Bot. ser. 6, **6:** 1–168.
6. GOEBEL, K.
1887 Outlines of Classification and Special Morphology. Clarenden Press. Oxford. Translated by Henry E. F. Garnsey; revised by I. B. Balfour.
7. GUEGUEN, F.
1903 Anatomie comparée du tissu conducteur du style et du stigmate des phanérogames. Journ. Bot. **16:** 15–30, 48–65, 138–144, 167–180, 300–313.
8. GUIGNARD, M. L.
1882 Recherches sur le sac embryonnaire des phanérogames angiospermes. Ann. Sci. Nat. Bot. ser. 6, **13:** 136–199.
9. 1882 Recherches sur le développement de l'anthére et du pollen des Orchidées. Ann. Sci. Nat. Bot. ser. 6, **14:** 26–45.
10. 1893 Recherches sur le développement de la graine et en particular du tégument séminal. Journ. Bot. **7:** 205–214.
11. GURKE, M.
1897 Borraginaceae. *In* Engler-Prantl, Naturliche Pflanzenfamilien IV, 3 abt. a: 71–131.
12. HALSTED, B. D.
1887 Three Nuclei in Pollen Grains. Bot. Gaz. **12:** 285–288.
13. HEGELMAIER, F.
1886 Zur Entwickelungsgeschichte endospermatischer Gewebekörper. Bot. Zeit. **44:** 544–555, 560–578.
14. HOFMEISTER, W.
1858 Neuere Beobachtungen über die Embryobildung der Phanerogamen. Pringsheim's Jahrb. **1:** 82–189.
15. JODIN, HENRI
1903 Recherches anatomique sur les Borraginées. Ann. Sci. Nat. Bot. ser. 8, **17:** 263–346.
16. JOHNSTON, IVAN M.
1923 Studies in the Boraginaceae. I–VIII. Contrib. Gray Herb. No. 68: 43–80.
1924 Ibid. No. 70: 3–61; No. 73: 42–73.
1925 Ibid. No. 74: 3–106; No. 75: 40–49.
1927 Ibid. No. 78: 3–73.
1928 Ibid. No. 81: 3–83.
1930 Ibid. No. 92: 3–95.
17. 1932 Studies in the Boraginaceae IX. Contrib. Arnold Arboretum **3:** 1–102.
18. JORDAN, K. F.
1892 Der Blüthenbau und die Bestäubungseinrichtung von *Echium vulgare*. Ber. deutsch bot. Ges. **10:** 583–586.

19. JOXE, A.
1912 Sur l'overture des fruits indéhiscents à la germination. Ann. Sci. Nat. Bot. ser. 9, **15**: 257–375.
20. JUEL, H. O.
1915 Untersuchungen über die Auflösung der Tapetalzellen in den Pollensäcken der Angiospermen. Jahrb. f. wiss. Bot. **56**: 337–364.
21. KRAUS, G.
1866 Über den Bau trockner Pericarpen. Pringsheim's Jahrb. **5**: 83–126.
22. LE MONNIER, M. G.
1872 Recherches sur la nervation de la graine. Ann. Sci. Nat. Bot. ser. 5, **16**: 233–305.
23. LOEW, E.
1886 Über die Bestäubungseinrichtungen einiger Borragineen. Ber. deutsch bot. Ges. **4**: 152–178.
24. 1892 Blüthenbiologische Beiträge II. Pringsheim's Jahrb. **23**: 207–253.
25. LÖTSCHER, B. K.
1905 Über den Bau und die Funktion der Antipoden in den Angiospermen-Samenanlage. Flora **94**: 213–232.
26. MOHL, H. VON.
1835 Sur la structure et les formes des grains de pollen. Ann. Sci. Nat. Bot. ser. 2, **3**: 148–180, 220–236, 304–346.
27. MOTTIER, D. M.
1895 Contributions to the Embryology of the Ranunculaceae. Bot. Gaz. **20**: 241–248.
28. MÜLLER, W.
1905 Beiträge zur Entwicklungsgeschichte der Inflorescenzen der Borragineen und Solaneen. Flora **94**: 385–419.
29. PAYER, J. B.
1857 Traité d'organogénie comparée de la fleur. Paris.
30. ROBIN, M.
1848 Sur l'existence d'un ovule chez les males comme chez les femelles des végétaux et des animaux. Compt. Rend. **3**: 428.
31. ROSANOFF, S.
1866. Morphologisch-embryologische Studien. Pringsheim's Jahrb. **5**: 72–82.
32. SCHACHT, H.
1860 Über den Bau einiger Pollenkörner. Pringsheim's Jahrb. **2**: 109–168.
33. SCHMIDT, C.
1888 Vergleichende Untersuchungen über die Behaarung der Labiaten und Borragineen. Inaugural Diss. Freiburg.
34. SCHURHOFF, P. N.
1926 Die Zytologie der Blütenpflanzen. Stuttgart. Verlag von Ferdinand Enke.
35. SVENSSON, HARRY G.
1925 Zur Embryologie der Hydrophyllaceen, Borraginaceen, und Heliotropiaceen mit besonderer Rucksicht auf die Endospermbildung. 178 pp. Inaugural Diss. Upsala.
36. TULASNE, L. R.
1849 Nouvelles études d'embryogénie végétale. Ann. Sci. Nat. Bot. ser. 4, **4**: 65–122.

37. VAN TIEGHEM, P.
1907 Structure du pistil et du fruit des Labiées, des Boragacées et des familles voisines. Ann. Sci. Nat. Bot. ser. 9, **5**: 321–350.
38. VESQUE, J.
1878 Développement du sac embryonnaire des phanérogames angiospermes. Ann. Sci. Nat. Bot. ser. 6, **6**: 237–285.
39. 1879 Le développement du sac embryonnaire des phanérogames angiospermes. Ann. Sci. Nat. ser 6, **8**: 261–390.
40. 1885 Charactères des principales familles gamopétales tirés de l'anatomie de la feuille. Ann. Sci. Nat. Bot. ser. **7**, **1**: 183–360.
41. WARMING, E.
1877 De l'ovule. Ann. Sci. Nat. Bot. ser. 6, **5**: 177–266.
42. WERNHAM, H. F.
1911 Floral Evolution with Particular Reference to the Sympetalous Dicotyledons. New Phytol. **10**: 293–305.
43. ZIRKLE, CONWAY
1930 The Use of N-butyl Alcohol in Dehydrating Woody Tissue for Paraffin Embedding. Science **6**: 103–104.

EXPLANATION OF PLATES

The drawings have been made at table level with the aid of a Spencer camera lucida and reduced to one third of the original size. Unless otherwise indicated the micropylar region of the embryo sac is turned toward the bottom of the page.

Abbreviations: *a.*, archesporial cell; *a.loc.*, anther locule; *ant.*, antipodal; *c.end.*, cellular endosperm; *c.i.c.*, collapsed integument cells; *cot.*, cotyledon; *d.i.*, disintegrating integument; *d.n.*, definitive nucleus; *e.*, egg; *em.*, embryo; *emb.c.*, embryo cells; *emb.s.*, embryo sac; *en.*, endosperm; *end.c.*, endosperm cells; *end.n.*, endosperm nucleus; *ep.*, epidermis; *f.e.*, fertilized egg; *f.m.*, functional megaspore; *fun.*, funiculus; *g.p.*, growing point; *i.*, integument; *i.c.*, integument cells; *in.l.*, inner layer; *m.l.*, middle layer; *m.v.*, median vein; *mic.*, micropyle; *nuc.*, nucellus; *o.*, ovule; *ov.w.*, ovary wall; *p.*, polar nucleus; *pa.*, parenchyma; *pc*, procambium; *p.d.*, point of dehiscence; *p.f.r.*, plasma fluid region; *p.g.*, pollen grain; *p.p.*, primary parietal layer; *p.sp.*, primary sporogenous tissue; *p.t.*, pollen tube; *r.*, radicle; *r.c.*, root cap; *s.*, sperm; *sp.*, spine; *sp.m.c.*, spore mother cell; *sp.t.*, sporogenous tissue; *sus.*, suspensor; *syn.*, synergid; *t.*, tapetum; *th.*, thickenings; *tr.*, tracheid.

PLATE 4

Cynoglossum amabile Stapf & Drumm.

1. Cross section of anther showing early differentiation of sporogenous tissue and primary parietal layer. × 572.
2. Longitudinal section of anther having two to three rows of sporogenous cells. × 572.
3. Cross section of an anther locule showing sporogenous tissue in a more advanced stage. Two parietal layers almost completed by means of periclinal walls and both increased in extent by anticlinal walls. × 572.
4. Section of anther showing completion of three parietal layers by periclinal division of the second parietal layer. × 572.

5. Cells of inner parietal layer increased in size and becoming differentiated as tapetal cells. Cells of middle parietal layer somewhat decreased in size. × 572.
6. Tapetal cells and their nuclei much enlarged. Middle parietal layer practically gone. Spore mother cells in spireme stage. × 572.
7. Diad stage of spore mother cells. Division taking place simultaneously. × 572.
8. Tetrad stage of the spore mother cells. Note large nuclei and vacuolated protoplasm of tapetal cells, and remnants of cells of the middle parietal layer. × 572.
9. Single spores entirely free from mother cell wall. Tapetal cells practically exhausted of cell contents. Mere remnants of the middle parietal layer present. Cells of outer parietal layer greatly increased in size and their walls somewhat thickened. × 572.
10. Segment of wall from mature anther consisting of epidermis and endothecium or outer parietal layer whose cell walls have become greatly thickened. Tapetum and middle layer completely gone. × 572.
11. Cross section of one lobe of mature anther showing the point of dehiscence between the two locules. × 184.
12. Diad stage of spore mother cell. × 572.
13. Spireme stage in preparation for heterotypic division of spore mother cell. × 572.
14. Group of spore mother cells in anaphase stage of the heterotypic division showing haploid number of chromosomes. × 572.
15. Early tetrad stage. × 572.
16. Spores rounded up within mother cell wall. × 633.
17. One-nucleate spore, long oval in shape, and constricted through mid-region. × 572.
18. Two-nucleate spore. × 572.
19. Three-nucleate spore. Two slightly oval sperm nuclei and the tube nucleus. × 572.
20. Same as 19 except that the sperm nuclei are more separated and the tube nucleus is near the constricted region where the pollen tube exits occur. × 572.
21. Section through young ovule showing the massive integument and relatively small nucellus. Single hypodermal cells becoming differentiated as the archesporial cell. × 370.
22. Integument closed over the nucellus. Nucleus of greatly increased archesporial cell in synapsis just preceding heterotypic division. × 572.
23. Three cells resulting from a periclinal division of the megaspore mother cell followed by an anticlinal division of the upper diad. The lower diad is the functional megaspore. Single layer of nucellus adjoining. × 633.
24. The upper diad has not divided. The lower diad has divided anticlinally and the larger cell is the functional megaspore. × 572.
25. Four megaspores. The larger basal cell is the functional one. All divisions have been oblique to the longitudinal axis of the ovule. × 572.
26. Four megaspores. First division was periclinal then upper diad divided anticlinally and lower diad periclinally. The basal megaspore is the functional one. × 572.

27. Longitudinal section through one locule of ovary showing relative position of ovule. Note that micropyle is directed toward region of style. This ovule contains the megaspores which are shown in Figure 26. × 60.

PLATE 5

Cynoglossum amabile Stapf & Drumm.

28. Longitudinal section through ovary and basal disc showing two ovules with their funiculi. × 60.
29. Cross section through a fairly mature ovary which appears to be quadrilocular due to the deep infolding and concrescence at the midpoint of the lateral walls of a bilocular ovary. × 27.
30. Abnormal ovary containing six ovules instead of four. × 27.
31. Two-nucleate embryo sac. × 572.
32. Section of embryo sac containing three nuclei. The adjoining section showed another nucleus in the antipodal end. × 572.
33. Eight-nucleate embryo sac. × 572.
34. Mature 8-nucleate sac. Egg apparatus organized and three antipodal cells formed. × 572.
35. Section showing micropylar end of embryo sac. A pollen tube has penetrated through the micropyle to the sac. One synergid has been destroyed and one sperm is near the egg nucleus. × 572.
36. Small section of the micropylar end of an embryo sac showing double fertilization. One sperm is near the egg nucleus, and the other is near the two polars which have not yet fused. Note the scattered cells of the inner region of the integument adjoining the embryo sac, and the path of the micropyle. A portion of pollen tube is also present. × 370.
37. Double fertilization. One sperm is passing over a synergid toward the egg. The two polar nuclei are in the process of fusion, and the second sperm is in contact with one of them. × 370.
38. Section of embryo sac containing a fertilized egg and the triple fusion nucleus in the spireme stage. × 237.
39. Cross section through an ovule showing the location of the 8-nucleate sac of Figure 34, and the regions of procambium in the funiculus and margin of the ovule. × 60.
40. A region of procambium from the margin of an ovule similar to those indicated in Figure 39. It is surrounded by parenchyma within and covered over on the outer side by one layer of epidermis. × 572.
41. Section through an ovule showing an 8-celled embryo with one suspensor cell and the free endosperm lining the embryo sac. A few endosperm nuclei show signs of becoming cellular in the micropylar region. × 246.
42. Free endosperm nuclei scattered around wall of an embryo sac. Note clumping of nuclei in micropylar end. × 184.
43. Somewhat older embryo with three suspensor cells. Endosperm nuclei becoming cellular about the embryo. × 370.
44. Cross section of ovule containing young embryo. Note the six regions of procambium around the margin and the inner region of the integument which is being disintegrated by the developing endosperm and embryo. The surrounding ovary wall is becoming spiny on the surface. × 27.

PLATE 6

Cynoglossum amabile Stapf & Drumm.

45. Longitudinal section through embryo sac near its margin. Endosperm has become cellular though inner cells are still very large. A portion of the plasma fluid region within is shown. Older embryo with three suspensor cells in micropylar end. × 104.
46. Eleventh section from the one shown in Figure 45 of the same embryo sac. Micropylar end of sac filled with cellular endosperm. Antipodal end shows a large fluid region within. × 104.
47. Section of maturing ovule. One complete layer of endosperm and a few scattered remnants of others are left about the embryo. The inner region of the integument is also in a state of disintegration. × 237.
48. Section of older ovule showing only one layer of endosperm left. All inner integument cells have been used up. Contents of some of the outer integument cells have also been absorbed so that the walls have collapsed. × 104.
49. Section of an almost mature ovule. The seed coat consists of an epidermis and the collapsed walls of practically all the outer integument cells. × 237.
50. Tracheids from ovule in Figure 51. × 246.
51. Section of ovule showing the rostrum, a projection about the mouth of the micropyle, and the tracheids in the fibrovascular tissue passing into the ovule from the funiculus. Regions of procambium cells lie between margin of ovule and the dotted lines. × 60.
52. Outline of embryo from a practically mature seed. The cotyledons have been pushed apart somewhat to show their relation to each other. × 8.
53. Section from the chalazal region of the ovule. Space within dotted lines represents procambial strands. A single strand from the funiculus breaks up into several branches that spread out over the surface of the ovule. × 104.
54. Longitudinal section through embryo of mature seed showing root cap region, radicle, growing point, cotyledons, and regions of procambium extending from the radicle up through each cotyledon. × 27.
55. Segment from region *a* of Figure 54. × 572.
56. Segment from region *b* of Figure 54. × 572.
57. Segment from region *c* of Figure 54. Note increase in thickness of epidermis of radicle as compared with that of the cotyledon. × 572.
58. Section from growing point region of the embryo shown in Figure 54. × 572.
59. Section from ovary wall at the time when the ovule contains an 8-nucleate embryo sac. Wall consists of three regions; an outer epidermal layer, a middle region composed of several rows of cells, and an inner layer, or epidermis. × 237.
60. Segment of ovary wall at the time when endosperm formation begins. The cells of the outer epidermis are more or less elongated as a preliminary stage to the formation of spines. Cells of the inner layer are well differentiated from those of the middle region. ×237.
61. Segment of outer epidermis of ovary wall showing net thickenings of the cell walls and small spine on the outer margin. ×246.

62. Segment of inner layer of ovary wall nearing maturity. Inner and lateral walls of cells considerably thickened. ×572.
63. Barbed spine from outer epidermis of mature ovary wall. Note smaller spines and net thickenings of cells along the lateral region of this epidermal outgrowth. The cells of the middle region project up into the spiny outgrowth. ×246.
64. Inner surface view of lignified cells of inner epidermis of practically mature ovary wall. Drawn from fresh material. ×184.

PLATE 4

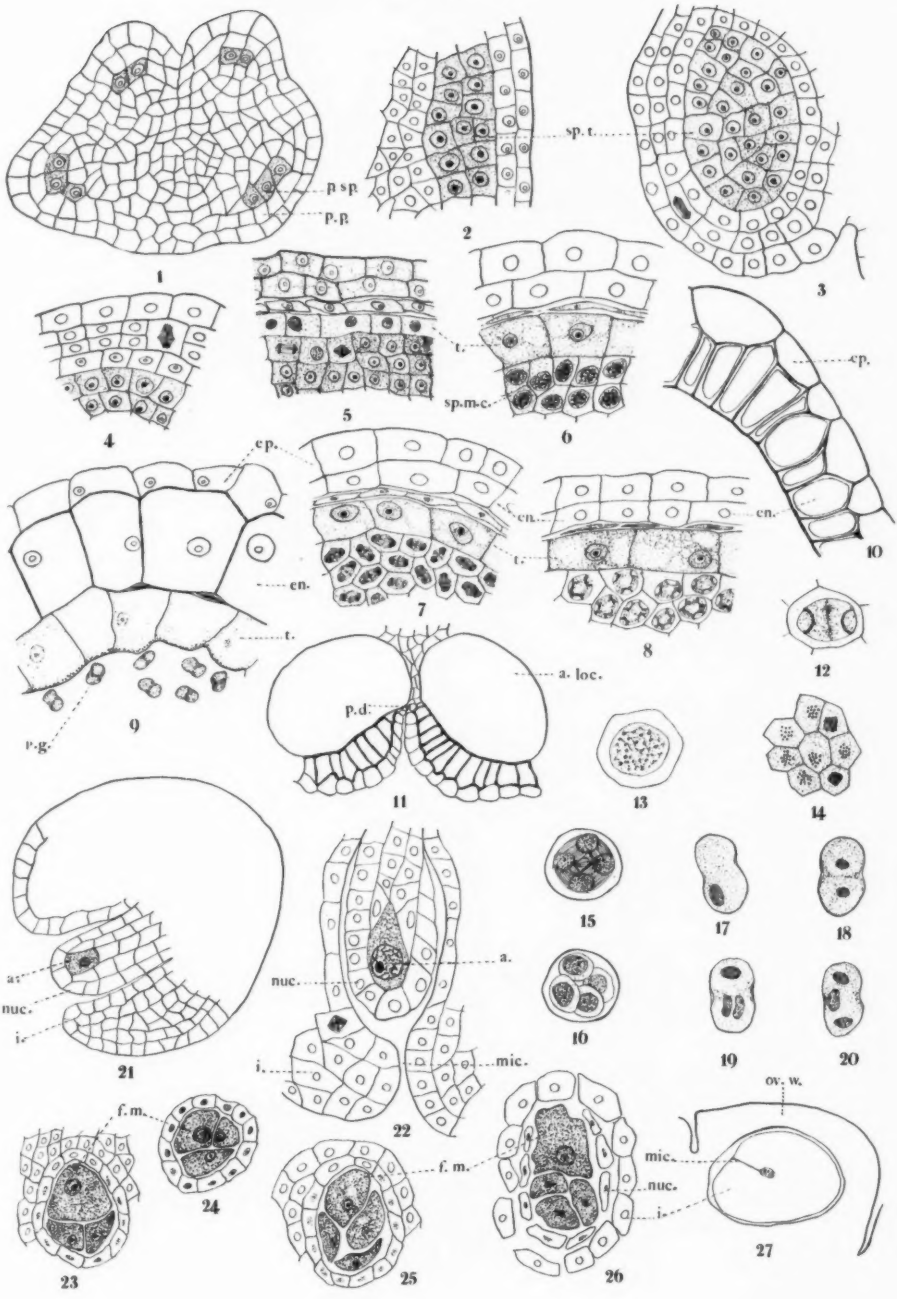

p.sp.
p.β
1
sp.t.
2
3
t.
sp.m.c.
4
5
6
ep.
ep.
en.
en.
en.
t.
7
8
10
12
t.
p.g.
9
a. loc.
p.d.
11
13
14
a.
nuc.
i.
21
15
17
18
a.
nuc.
mic.
i.
22
16
19
20
f.m.
24
23
f. m.
25
26
ov. w.
mic.
nuc.
i.
27

PLATE 5

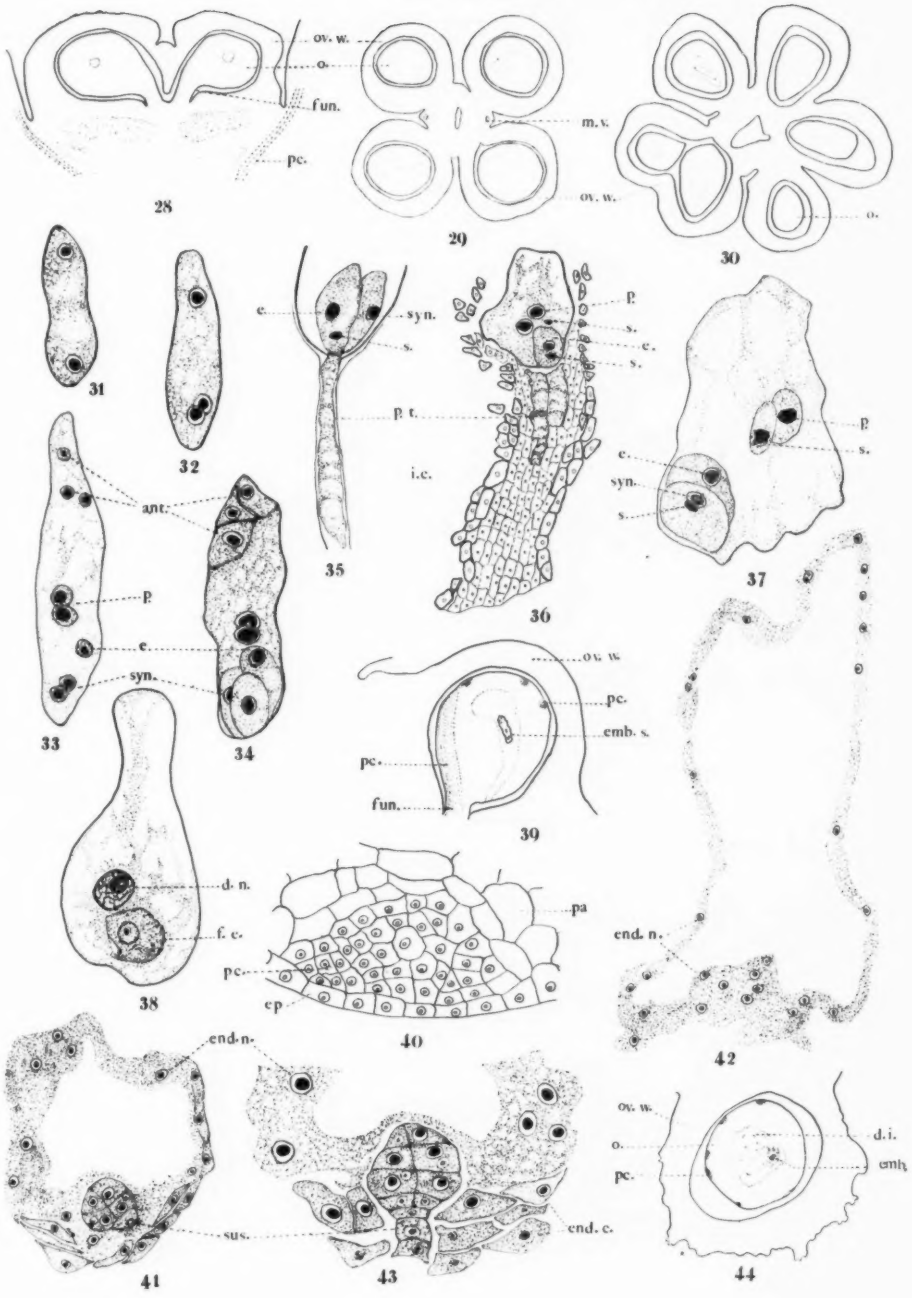
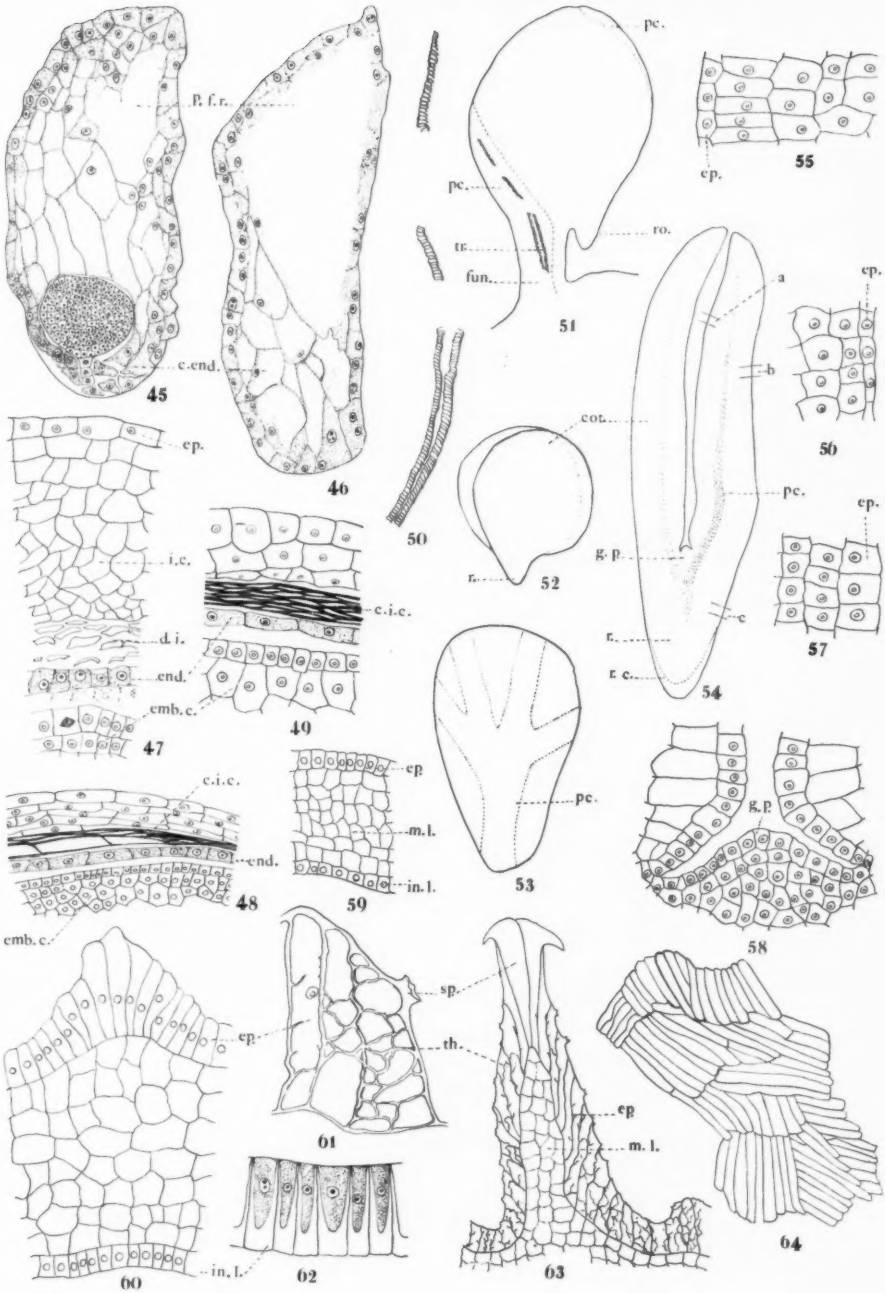

ov. w.
o.
fun.
pc.
28
m. v.
ov. w.
29
o.
30
31
32
c.
syn.
s.
p. t.
35
i.c.
p.
s.
c.
s.
36
p.
s.
c.
syn.
s.
37
ant.
p.
c.
syn.
33
34
ov. w.
pc.
emb. s.
pc.
fun.
39
d. n.
f. c.
pc.
38
pa
end. n.
ep
40
end. n.
42
end. n.
sus.
41
end. c.
43
ov. w.
o.
pc.
d. i.
emb.
44

PLATE 6


p. f. r.
c.end.
45
46
pc.
pc.
tr.
fun.
ro.
51
ep.
55
a
b
ep.
50
cot.
pc.
g. p.
r.
52
50
ep.
i.c.
d. i.
end.
emb. c.
47
c. i. c.
49
ep.
57
r.
r. c.
54
pc.
53
c. i. c.
end.
48
ep
m. l.
in. l.
59
g. p.
58
emb. c.
ep.
sp.
th.
ep
m. l.
61
64
in. l.
60
62
63

STUDIES IN THE GENUS OLPIDIOPSIS. III

Some Observations on the Host Range of Certain Species*

By Leland Shanor

Very little is known about the host range of any of the species of *Olpidiopsis*. The only available information on this problem seems to be from isolated reports of *Olpidiopsis* species occurring on the various hosts. There are only a few records where attempts have been made to transfer species from one host plant to others. In spite of this lack of definite information, one important factor that has been used in determining species, besides the morphological characters of the resting spores, has been the host genus on which certain species have been observed. This has been particularly true in the case of species that parasitize water molds. Collection records also report species which are considered normally to parasitize *Saprolegnia* as occurring on *Achlya* and species which normally parasitize *Achlya* as occurring on *Saprolegnia*. The host plant in most instances was not isolated in pure culture and frequently was not even unquestionably identified.

Very soon after beginning collections for a taxonomic study of the genus, the importance of an accurate determination of the host became more obvious. In several instances when *Olpidiopsis* appeared parasitizing water molds, as they grew on hemp seed which had been placed in water samples, all of the hyphae of one water mold would be infected, leaving the hyphae of the others to fruit. In many cases the hyphae of the infected host were so similar to those of the non-infected plant that all appeared to belong to the same species. Because of this fact, it was obvious that in most cases the only way to identify a host plant accurately would be to obtain a pure culture of it by placing a young parasitized hypha on agar. Also because of this difficulty in determining the infected plant in a mixed water mold culture, some

* This study was carried out in the Botanical Laboratories of the University of North Carolina under the direction of Dr. W. C. Coker. The author wishes to express his sincere appreciation to Dr. Coker for his guidance and for his continual interest in the problem. He is also grateful to Dr. J. N. Couch for many helpful suggestions.

of the host plants reported in the literature may be considered of doubtful identification. In recent years methods for the isolation and pure culture of the fungi have been greatly improved and it has been only rather recently that pure cultures of many of the fungi or their parasites have been carried on for any length of time. This has made possible not only a more accurate study of many forms but also a better understanding of their parasites.

Before discussing the results of the study on the host range of certain species of *Olpidiopsis* that occur on water molds, I would like to review the status of one species, *Olpidiopsis incrassata*, described by Cornu (1872) as a parasite of *Achlya*. At the time this species was discovered, Cornu was not sure of certain points in its morphology and had collected it only a single time. The walls of the resting spores of *O. incrassata* were described as being irregularly deposited and of a yellowish or yellowish brown color. Fischer (1892) transferred Cornu's plant to his new genus, *Pseudolpidium*, principally because of the incompleteness of certain of Cornu's observations. At the same time, he described a species occurring on *Saprolegnia* whose resting spore walls were also covered with wart-like protuberances. Fischer thought that his plant was *Olpidiopsis Saprolegniae* which had been described by Cornu, for it parasitized several species of *Saprolegnia*. Barrett (1912) has pointed out that Cornu and Fischer were considering two different plants under the same name, *Olpidiopsis Saprolegniae*, and has described Fischer's plant as new, naming it *Olpidiopsis vexans*.

Maurizio (1895), when describing *Olpidiopsis major* on *Saprolegnia*, remarks upon the similarity of the resting spore wall of his plant to that of the resting spore of *O. incrassata* Cornu, both as to the color of the resting spore wall and as to the irregular manner in which it is deposited. However, he considers Fischer justified in transferring *O. incrassata* Cornu to the genus *Pseudolpidium*. McLarty (1939) has pointed out that of the six species placed in *Pseudolpidium* by Fischer only two could be considered as tenable, because Fischer did not observe the resting spores of the other four. *Pseudolpidium* (*Olpidiopsis*) *incrassata* is one of these four species. Recently the present author (Shanor, 1939,b) has raised the question as to whether any of the species proposed by Fischer for his genus *Pseudolpidium* were good species and concludes that none of the species included here by Fischer can remain unquestionably in the genus *Pseudolpidium*. The validity of the genus itself is very questionable. *Olpidiopsis major* Maurizio has been considered by Coker (1923) as doubtfully distinct from the

plant described as *O. Saprolegniae* sense of Fischer (*O. vexans* Barrett). I am of the opinion that *O. Saprolegniae* (Cornu) amend. Fischer, *O. vexans* Barrett, and *O. major* Maurizio are all synonymous with *O. incrassata* Cornu and have listed this species as such in the following tables. A careful study of the descriptions and figures of all of the above named species shows the remarkable similarities which exist and, in addition, the information gained from this host range study and from the comparison of many collections has led me to this conclusion. Cornu's report of *O. incrassata* as a parasite of *Achlya* was probably an error. He made no attempt to obtain pure cultures of his host plant. From the observations which follow, it appears that *O. incrassata* is a natural parasite of *Saprolegnia* and may occur on certain species of *Isoachlya*.

Because my original collections were found parasitizing *Saprolegnia* and because I had felt that more collections were necessary for comparative purposes, I had at first (Shanor, 1939,b) considered what I now believe to be *O. incrassata* as *O. vexans* Barrett. Figures and photographs of the various forms of *O. incrassata*, along with a more detailed discussion of the reasons for the confusion that has existed in connection with the taxonomy of this species, will be presented in a later taxonomic paper.

PROCEDURE

Stock cultures of all of the host species were kept in petri dishes and washed and transferred frequently to eliminate as much bacterial contamination as possible. These cultures were grown on halves of boiled hemp seed in distilled water which was prepared in the usual way.

Stock cultures of the parasite species were kept going on their original hosts and transfers made every three or four days to insure as pure cultures as possible. These were washed every morning and evening to keep down the bacterial contamination. Frequently young pure cultures of the original host were added in order to obtain a good vigorous infection quickly. Usually cultures to be used in the transfer experiments were made in this way.

In attempting to transfer the parasite from one host to another, only clean young cultures of the host and cultures vigorously parasitized by a species of *Olpidiopsis* were used. By young cultures of the host we refer to cultures grown on hemp seed which were removed from a stock culture about 24 hours after the hemp seed had been dropped into it and from which the hyphae were extending outward about a

millimeter in every direction. It has been found that cultures of about this age are probably more susceptible to any species of *Olpidiopsis*, if susceptible at all, than are those of any other age. If a host is susceptible to an *Olpidiopsis* species, the infection of a culture which is this age will take place very soon after the parasitized culture is introduced into the petri dish with it. The infection obtained at this time is also much more vigorous. This is a decided factor in making a definite conclusion as to the susceptibility of any given host.

In most cases at least two separate attempts have been made to obtain parasitism of each host species by each of the species of *Olpidiopsis*. This was done by placing a parasitized culture in a petri dish in distilled water along with a single pure culture of the possible host. In cases where a species has been reported as parasitizing a given water mold but in which I had been unable to obtain parasitism, as many as eight such attempts have been made. In the tables, the number of such attempts to effect a transfer of a parasite to a host is indicated in the upper right hand corner of each block in which susceptibility is shown. In addition to these separate single host culture exposures to the parasite species, each host has been exposed along with one or two others in the same petri dish to determine if the presence of other species might have any effect upon the susceptibility of any of them. These exposures have not given different results from the exposure of a single host to a single parasitized culture and are not listed in the table of exposures given under the observations.

All host cultures were examined after twenty-four hours' exposure to a heavily parasitized culture. If a species of *Olpidiopsis* is able to parasitize a given host at all, the swollen infected hyphae will be evident at this time. Then too, an examination at this time greatly reduces the possibility of mistaking a growth of hyphae from the spores of the introduced parasitized host which might become infected for hyphae of the species being exposed. If no infection was noted at this time, cultures were left exposed to the parasitized culture for four days and were examined again on the second day and before being discarded.

If a culture failed to show any signs of being parasitized after 24 hours but had some hyphae that were parasitized later, hyphae containing an early infection were carefully removed, washed thoroughly in distilled water, and placed on a sterilized plate of maltose-peptone #5 agar to obtain a pure culture of the host from the infected thread. Small blocks of the agar containing this growth were then cut out and placed in sterile petri dishes. A half of a hemp seed was then placed

on each block and treated distilled water was added to these. In this way pure cultures of the host were obtained from the infected thread which could be accurately identified. This identification would prove whether the infected thread was that of the species being tested or one which had grown from a spore of the introduced parasitized host. Running an infected thread back through agar to obtain a pure culture seemed to be the most effective means of checking accurately on the exact species parasitized.

If the infection of most of the hyphae of an exposed culture is evident after twenty-four hours' exposure, this running back of an infected thread through agar is unnecessary. In questionable or surprising instances of parasitism, however, this was done to verify the original reading. In all, two hundred and sixty-four single host exposures have been made.

The classification of the host species followed is that of Coker and Matthews (1937) in North American Flora.

OBSERVATIONS

Of the five species of *Olpidiopsis* used in this host range study, two, *O. varians* and *O. fusiformis*, are considered as natural parasites of *Achlya*. Two species, *O. Saprolegniae* and *O. incrassata*, are considered as natural parasites of *Saprolegnia*. The reason for the last named species being considered as such is explained in the introductory part of this paper. The fifth species of *Olpidiopsis*, *O. luxurians*, is a natural parasite of *Aphanomyces*.

As is indicated in Table I, attempts to transfer the species which normally parasitize *Achlya* to species of *Saprolegnia* have all been unsuccessful. It is also shown that each of the species which usually occur on *Saprolegnia* are not restricted to any species or groups within the genus but are capable of parasitizing all species so far exposed to them.

Olpidiopsis Saprolegniae has appeared to be a more vigorous parasite than *O. incrassata*. Almost all of the hyphal tips of the introduced host became infected and began to swell very soon after the host exposure was made. The tip swellings produced by this parasite are very characteristic and few intercalary infections seem to occur. More intercalary infections have been noted on species of *Saprolegnia* in the Diclina Group than on species in the Ferax Group. On the other hand, the terminal swellings of the host and the sporangia and resting spores of the parasite developed on members of the Ferax Group reached

larger proportions than did those produced on species in the Diclina Group.

Olpidiopsis incrassata appears to be a slightly more vigorous parasite on species of *Saprolegnia* in the Ferax Group than on those in the Diclina Group. Most of the young hyphae of species in the Ferax Group which have become infected by *O. incrassata* are parasitized in their apical portions and the typical more or less oval, terminal swellings result. On young cultures of species in the Diclina Group, both terminal and intercalary infections occur. As was noted for *O. Saprolegnia* above, the largest sporangia and resting spores were again produced on *Saprolegnia* species in the Ferax Group.

TABLE I

PARASITE SPECIES	HOST SPECIES					
	S. diclina	*S. delica*	*S. ferax*	*S. mixta*	*S. monoica* (?)	*S. litoralis*
O. varians	2	2	2	2	2	2
	−	−	−	−	−	−
O. fusiformis	2	2	2	2	2	2
	−	−	−	−	−	−
O. Saprolegniae	H	1	1	1	1	2
	+	+	+	+	+	+
O. incrassata	1	1	H	1	1	2
	+	+	+	+	+	+
O. luxurians	2	2	2	2	2	2
	−	−	−	−	−	−

In the above table susceptibility of a host is indicated by a + and failure to obtain parasitism is indicated by a −. The original host species on which the isolate used in these experiments was found is indicated by an H. The number of attempts to bring about a transfer to a host species is given above the sign indicating susceptibility.

Olpidiopsis luxurians has shown no indications of being able to parasitize any of the species of *Saprolegnia* used in this study.

The host range of the *Olpidiopsis* species which normally parasitize *Achlya* as is indicated in Table II seems to be much more restricted than that of species which normally parasitize *Saprolegnia*. *Olpidip-*

sis varians parasitizes *Achlya flagellata* and *A. proliferoides* very vigorously. *Achlya racemosa* and *A. colorata* may be parasitized to a slight degree but the parasite sporangia produced in the hyphae of these two species were never as large as those on *A. flagellata* or *A. proliferoides* and some of them appear never to mature.

Olpidiopsis fusiformis was found to parasitize *Achlya imperfecta* and *A. Klebsiana* rather vigorously and to infect *A. racemosa* to a slight

TABLE II

PARASITE SPECIES	HOST SPECIES									
	A. racemosa	*A. colorata*	*A. americana*	*A. proliferoides*	*A. flagellata*	*A. imperfecta*	*A. Klebsiana*	*A. recurva*	*A. apiculata*	*A. glomerata*
O. varians	4	4	3	2	H	8	2	2	2	2
	+	+	−	+	+	−	−	−	−	−
O. fusiformis	4	4	3	2	7	H	2	2	2	2
	+	−	−	−	−	+	+	−	−	−
O. Saprolegniae	2	2	2	2	2	2	2	2	2	2
	−	−	−	−	−	−	−	−	−	−
O. incrassata	2	2	2	2	2	2	2	2	2	2
	−	−	−	−	−	−	−	−	−	−
O. luxurians	2	2	2	2	2	2	2	2	2	2
	−	−	−	−	−	−	−	−	−	−

(Legend same as for Table I.)

degree. The sporangia produced on *A. racemosa* were small and again many never developed completely.

Olpidiopsis varians is a more vigorous parasite than *O. fusiformis.* Attempts to transfer *O. fusiformis* to *Achlya colorata* and to *A. proliferoides* or to transfer *O. varians* to *A. Klebsiana* have been unsuccessful. Likewise, many attempts to transfer each of these two parasite species to the original host of the other have not resulted in any infection. This is a very interesting situation in view of the fact that *Achlya flagellata* and *A. imperfecta* are very closely related morphologically.

Olpidiopsis Saprolegniae, *O. incrassata*, and *O. luxurians* have not given the slightest indication of parasitizing any of the species of *Achlya* shown in Table II.

In addition to species of *Achlya* and *Saprolegnia*, representatives of several other genera as given in Table III were exposed to the five species of *Olpidiopsis* which commonly occur on members of the Saprolegniaceae. *Isoachlya anisospora*, *I. unispora*, and *I. eccentrica* all were found to be susceptible to *Olpidiopsis Saprolegniae* while the first two species were susceptible to *O. incrassata*. *Isoachlya anisospora*

TABLE III

PARASITE SPECIES	HOST SPECIES								
	Aplanes Treleaseanus	*Protoachlya paradoxa*	*Isoachlya anisospora*	*Isoachlya unispora*	*Isoachlya eccentrica*	*Aphanomyces laevis*	*Aphanomyces stellatus*	*Dictyuchus sp. (sterile)*	*Leptolegnia sp. (sterile)*
O. varians	2	2	2	2	2	2	2	2	2
	−	−	−	−	−	−	−	−	−
O. fusiformis	2	2	2	2	2	2	2	2	2
	−	−	−	−	−	−	−	−	−
O. Saprolegniae	2	2	1	4	4	2	2	2	2
	−	−	+	+	+	−	−	−	−
O. incrassata	2	2	2	3	4	2	2	2	2
	−	−	+	+	−	−	−	−	−
O. luxurians	2	2	2	3	2	H	4	2	2
	−	−	−	−	−	+	−	−	−

(Legend same as for Table I.)

was as vigorously parasitized as any of the species of *Saprolegnia* by both of the above named parasites and *I. unispora* showed a clear susceptibility to both. *Isoachlya eccentrica* appears to be immune to parasitism by *O. incrassata* but is somewhat susceptible to *O. Saprolegniae*. Both parasites cause the formation of terminal swellings on *I. anisospora*, typical of the infection produced on *Saprolegnia*. On the other two species, the swellings are much more frequently intercalary and appear remarkably similar to those produced by *Olpidiopsis luxurians* on *Aphanomyces laevis*. Parasitism by *O. Saprolegniae*

on all species of *Isoachlya* appears to be more vigorous than that of *O. incrassata.*

Olpidiopsis luxurians has shown no indication of parasitizing any other host than *Aphanomyces laevis,* the plant on which it was originally collected. In this respect it has been much more specific in the selection of hosts than any of the other species of *Olpidiopsis* studied. In addition to the host species listed in the three tables, attempts have also been made to transfer *O. luxurians* to *Pythium aphanidermatum* and to *P. gracile,* but no infection has occurred.

All host species shown in Table III seem to be immune to the species of *Olpidiopsis* which normally occur on *Achlya.*

DISCUSSION

Besides the importance of the host plant in the identification of many of the species of *Olpidiopsis,* the reaction to parasitism by the host may be an indication of closer host relationships in cases where the parasite is not confined to a single host species. Many species of endophytic parasites of the water molds have very restricted host ranges and are obligate parasites. Among those considered as obligate endophytic parasites of water fungi recently described are *Rozella allomycis,* found in the hyphae of *Allomyces arbuscula* (Foust, 1938), *Octomyxa achlyae,* parasitic on *Achlya glomerata* (Couch, Leitner, and Whiffen, 1939), and *Pringsheimiella dioica,* occurring in the hyphae of *Achlya flagellata* (Couch, 1939). Besides these, there are many other species where only a single host is known. Not all species of *Olpidiopsis* confine their parasitism to a single host, but the range of host plants in all cases seems to be rather clearly limited. In the case of *Olpidiopsis luxurians* the host range seems to be restricted to a single species as is shown, and the others seem to confine their parasitism to a single genus or to closely related genera.

The species of *Olpidiopsis* which normally parasitize *Saprolegnia* have a wider host range than any of the other species. If susceptibility to a parasite can be taken as an indication of relationship, *Isoachlya* is very definitely related more closely to *Saprolegnia* than to *Achlya. Isoachlya anisospora,* the species whose morphological characters most closely approach those of *Saprolegnia,* shows as much susceptibility to both species that are normally found on *Saprolegnia* as do species of *Saprolegnia. Isoachlya eccentrica,* the species whose characteristics show a leaning toward *Achlya,* is not susceptible to the less vigorous of the two species of *Olpidiopsis* which normally occur on *Saprolegnia.*

Likewise, no species of *Achlya* showed any susceptibility when exposed to any of the species that normally occur on *Saprolegnia*. *Olpidiopsis Saprolegniae* has been reported as occurring on *Achlya* sp. (?) by Sparrow (1932). Coker (1923) found what he considered to be *O. Saprolegniae* Cornu amend. Fischer on *Achlya flagellata* and *Achlya imperfecta*. Coker points out, however, the differences that exist between his plant and that described by Fischer (1892), and it appears that Coker's plant may have been the variable species, *O. varians*, recently described by the present author (Shanor, 1939, a).

As indicated by their reaction to parasitism by the species of *Olpidiopsis* which are normally found on *Achlya*, the relationship of all species of *Achlya* to each other is not as clearly brought out as was the relationship of the species of *Saprolegnia*. Certain very interesting points, however, were observed.

From the morphological standpoint, the Racemosa Group and the Prolifera Group of the genus *Achlya* are rather widely separated. Selected members of both groups, however, showed susceptibility to both species of *Olpidiopsis* which normally parasitize *Achlya*. Both *Olpidiopsis varians* and *O. fusiformis* were found to be more vigorous parasites of species in the Prolifera Group than of species in the Racemosa Group. The poor development of the sporangia of the parasite on species in the Racemosa Group might indicate that this group is more nearly related to *Saprolegnia*, since no species of *Saprolegnia* was found susceptible to those species of *Olpidiopsis* which are normal parasites of *Achlya*. Then too, the less vigorous of the two species of *Olpidiopsis* that are normally found on *Achlya* parasitized only one species in the Racemosa Group and that one only very weakly.

Perhaps the most interesting observation made from the host range study of the species of *Olpidiopsis* which normally parasitize *Achlya* is the host selectivity exhibited by these parasities within the Prolifera Group of the genus. The original hosts of *Olpidiopsis varians* and *O. fusiformis*, i.e. *Achlya flagellata* and *A. imperfecta*, are very closely related morphologically, yet repeated attempts to transfer both parasites to the original host of the other were unsuccessful. In addition, another closely related host species, *Achlya proliferoides*, is very susceptible to *O. varians* but is immune to *O. fusiformis*. On the other hand, *Achlya Klebsiana* is susceptible to *O. fusiformis* and not to *O. varians*. Such host selectivity shows very clearly the definite physiological differences that may exist within groups whose species show close morphological relationships.

Matruchot (1903) obtained some very striking results in connection

with the relationships within the Mucorales by their reactions to parasitism by *Piptocephalis Tieghemiana*. Species in the two tribes, the Pilobolées and the Mucorées, were found to be susceptible to *Piptocephalis*, while species in the other two tribes, the Mortiérellées and the Syncéphalidées, would resist parasitism. He concluded from this that parasitism of a species by *Piptocephalis* would indicate a relationship to one of the first two groups.

Couch (1926) has observed that *Aphanomyces exoparasiticus* was able to parasitize all species of Phycomycetes that were tested but was unable to parasitize the Ascomycetes or Basidiomycetes to which attempted transfers were made.

Although no generalizations pertaining to the relationships of species in the Saprolegniaceae can be assumed from their reaction to parasitism by all species of *Olpidiopsis*, the morphological relationships of some of the members of this family, as already accepted, seem to be further emphasized by their reactions to parasitism by certain species.

SUMMARY

A study of the host range of certain species of *Olpidiopsis* which occur as parasites of the water molds has been made in which twenty-five species representing eight genera of the Saprolegniaceae were used as possible hosts. In all, two hundred and sixty-four single host exposures have been made. Two species, *Olpidiopsis varians* and *O. fusiformis*, confine their parasitism to species of *Achlya*. *Olpidiopsis varians* parasitizes *Achlya flagellata* and *A. proliferoides* very vigorously and *A. racemosa* and *A. colorata* only to a very slight degree. *Olpidiopsis fusiformis* parasitizes *A. imperfecta* and *A. Klebsiana* vigorously and *A. racemosa* only slightly. Two other species, *Olpidiopsis Saprolegniae* and *O. incrassata* were found to parasitize all species of *Saprolegnia* exposed to them. *Olpidiopsis Saprolegniae* is also capable of parasitizing *Isoachlya anisospora*, *I. unispora*, and *I. eccentrica* while *O. incrassata* has parasitized only *I. anisospora* and *I. unispora*. *Olpidiopsis incrassata* is considered a natural parasite of *Saprolegnia* and this conclusion is explained. The host range of *Olpidiopsis luxurians* appears to be confined to a single species, *Aphanomyces laevis*.

The relationships of certain of the host genera and species as is indicated by their reaction to parasitism by species of *Olpidiopsis* are discussed.

DEPARTMENT OF BOTANY AND BACTERIOLOGY,
CLEMSON AGRICULTURAL COLLEGE,
CLEMSON, SOUTH CAROLINA.

LITERATURE CITED

1. BARRETT, J. T. 1912 Development and Sexuality of Some Species of *Olpidiopsis*, (Cornu) Fischer. Ann. Bot. **26**: 209–238.
2. COKER, W. C. 1923 The Saprolegniaceae. 201 pp. University of North Carolina Press, Chapel Hill, N. C.
3. ———, AND VELMA D. MATTHEWS 1937 Saprolegniaceae. North American Flora. Vol. 2, Part 1, pp. 17–58.
4. COUCH, J. N. 1926 Notes on the Genus *Aphanomyces*, with a Description of a New Semiparasitic Species. Journ. Elisha Mit. Sci. Soc. **41**: 213–227.
5. ——— 1939 Heterothallism in the Chytridiales. Journ. Elisha Mit. Sci. Soc. **55**: 409–414.
6. ———, Jean Leitner, and Alma Whiffen 1939 A New Genus of the Plasmodiophoraceae. Journ. Elisha Mit. Sci. Soc. **55**: 399–408.
7. Cornu, M. 1872 Monographie des Saprolegniées. Ann. des Sci. Nat. Bot., ser. 5, **15**: 1–198.
8. FISCHER, A. 1892 Phycomycetes. Rabenhorst's Kryptogamenflora von Deutschland, I, Vol. 4.
9. FOUST, FRANCES K. 1938 Studies on *Rozella* and *Pleolpidium*. Unpublished thesis in the Department of Botany, University of North Carolina, Chapel Hill, North Carolina.
10. MATRUCHOT, L. 1903 Une Mucorinée purement conidienne, *Cunninghamella africana*. Ann. Myc. **1**: 45–60.
11. MAURIZIO, A. 1895 Zur Kenntniss der Schweizerischen Wasserpilze nebst Angaben über eine neune Chytridine. Jaresber. Naturf. Ges. Gräubundens, Chur. **38**: 9–38.
12. MCLARTY, D. A. 1939 Observations on the genus *Pseudolpidium*. Am. Journ. Bot. **26**: 194–195.
13. SHANOR, LELAND 1939a Studies in the Genus *Olpidiopsis*. I. Resting Spore Germination in a New Species. Journ. Elisha Mit. Sci. Soc. **55**: 167–177.
14. ——— 1939b Studies in the Genus *Olpidiopsis*. II. The Relationship of *Pseudolpidium* Fischer and *Olpidiopsis* (Cornu) Fischer. Journ. Elisha Mit. Sci. Soc. **55**: 179–195.
15. SPARROW, F. K., JR. 1932 Observations on the Aquatic Fungi of Cold Spring Harbor. Mycologia **24**: 268–303.

NOTES ON PLANKTON ENTOMOSTRACA OF THE CAROLINAS

By Paul W. McKee and R. E. Coker

INTRODUCTION

The fresh-water Entomostraca of the southeastern region of the United States are so little known in respect to species and distribution that a brief report of collections made in a number of waters in the late winter and spring of 1938 may be of value.

The Carolinas are, of course, without natural mountain lakes. The only natural lakes in North Carolina worthy of the name are in the extreme eastern part of the State on the lower part of the Coastal Plain. Notable among these are: Mattamuskeet with an area of about 35,000 acres, a length of about 16 miles, a width of about 6, and a depth probably nowhere exceeding 8 or 10 feet; Phelps Lake in Washington County about half as large but probably considerably deeper in the deepest part; Waccamaw Lake covering about 15,000 acres; Black Lake with an extent of some 2,100 acres; and White Lake ($2 \times 1\frac{1}{4}$ miles) an area of about 1,000 acres concerning which one of the authors has reported in another paper (Coker, 1938a). None of these lakes are more than 50 miles (80 km.) from the coast, and Mattamuskeet is only a mile or two from the coastal Sound of Pamlico.

The term "lake" has, however, long been applied locally to lagoons of different forms and sizes in river swamps, representing abandoned sections of river bed. Even the larger and more open millponds, such as Crystal Lake at Lakeview near Southern Pines, are known as lakes. In comparatively recent years there have been formed a number of power lakes, some of them having extended shorelines, great surface area and considerable depth. Examples of these are: Lake James with a deeply indented shoreline of nearly 150 miles and a surface extent of some 10 square miles (see Coker, 1926). Undoubtedly the largest of these in the Carolinas is Lake Murray on the Saluda River near Columbia, South Carolina, with a length of 35 miles, a reputed shoreline of 525 miles and a maximum depth when full to the top of the spillway of 200 feet. The reservoirs above power dams or municipal water supply dams, however lake-like they may be in size, depth and general clearness, are subject to vicissitudes that are not common to

natural lakes, in that there may be, according to the fluctuations of supply and demand, notable changes in depth and extent. Furthermore these larger lakes are all comparatively new and immature, so that it may be interesting to make a later comparison between the compositions of the plankton at the present and at some future time. Our immediate purpose, however, was not to make such a comprehensive and intensive study as would be desirable with appropriate means and time, but rather to gain a clearer general idea of what sort of plankton occurs in the sorts of waters characteristic of the region. We have, then, examined and are reporting upon casual collections made in a number of different waters representing most of the types found in North Carolina and to some extent also in South Carolina.

Collections were made in 33 lakes and ponds, natural and artificial, small and larger, from near the eastern border of the Coastal Plain to the Piedmont. Collections were made with the use of a boat when available or by casting from the shore with a 12-inch silk plankton net. Except in regard to the larger ponds or waters for which there is authentic data, information in regard to area and depth is generally given only in approximate terms and on the authority of local informants.

The field work done by Mr. McKee was made possible by a grant from the Smith Research Fund. This report includes also some records made previously by others as indicated in the list of waters. All copepods taken were accurately identified, but, when only copepods of very general distribution were found, no record is made in Table 1 (p. 179). Cladocera are recorded in the Table only as they were particularly abundant or as their presence was otherwise noteworthy. Following is a list of the waters examined with brief comment on each.

WATERS FROM WHICH COLLECTIONS WERE MADE

(The asterisk(*) following the name of a water indicates that collections were made by others than McKee)

Alligator Lake ("New Lake"), Hyde Co., N. C.: large swamp lake of about 6,000 acres, with drainage from surrounding swamp; much wood and debris piled along shore; many snags; water in 100 cc. bottle pale coffee color. *C. agilis* Koch (*"C. serrulatus"*) also found. 2/6/38.

Baker Lake, Bladen Co., N. C.: natural lake of about 576 acres, draining into the Cape Fear River; water in 100 cc. bottle slightly yellow. *Cyclops albidus* Jurine abundant in addition to those mentioned. 2/12/38.

Table Showing Waters From Which Collections Were Made and Species of Special Interest Taken.*

	Daphnassoma leuchtenbergianum Fischer	D. brachyurum (Liévin)	Sida crystallina (O.F. Müller)	Holopedium amazonicum Stingelin	Daphnia pulex (de Geer)	D. longispina (O.F. Müller)	Ceriodaphnia acanthina Ross	C. lacustris Birge	C. pulchella Sars	Acantholeberis curvirostris (O.F. Müller)	Eurycercus lamellatus (O.F. Müller)	Polyphemus pediculus (Linné)	Leptodora kindtii (Focke)	Eurytemora hirundoides Nordquist	Epischura nordenskiöldi Lilljeborg	Diaptomus reighardi Marsh	D. birgei Marsh	D. minutus Lilljeborg	Cyclops bicuspidatus thomasi S. Forbes	C. leuckarti Claus	C. prasinus Fischer	C. fimbriatus poppei (Rehberg)	C. nanus Sars	Canthocamptus sinuus Coker	C. staphylinoides vagus Coker and Morgan
Alligator Lake (New Lake)																				C			R		C
Baker Lake	C					C														C					R
*Black Lake															X										
Blewett Falls Lake						C										X				C					
*Lake Brandt	X					X	X										X			X	X				
Bryant's Millpond						A														A					
*Crystal Lake (Lakeview)				X	X	X					X														
Lake Ellis																					C				X
Everett's Lake					A						X					X				X					
Garner's Lake No. 1																C					C				
Garner's Lake No. 2																C								X	
High Rock Lake	X				A											C				C					
Lake James					A												X			X					
Jones Lake																					C				
Lennon's Millpond												C													R
*Loch Lily	X																			X					
Lookout Shoals Lake	X				X												X		X	X					
Mark Creek Lake	C			A		A																			
*Lake Mattamuskeet														X		X				X					
*Lake Michie						C											C			C					
*Mills Pond						X														X					
Mountain Island Lake	X				X												X		X						
Lake Murray		C			C	C										C				C					
Norwood Lake						X										X				X					
Odum's Millpond																				C					R
*Ogburn Lake					X				X								X			X	X				
Oxford Lake	X				X												X			X					
Page's Lake						C									C					C					
Phelps Lake	C												R							R		R			R
Pungo Lake																				C					R
Railroad Pond	C															C									
(Roadside Canal)																									R
Little Singletary Lake															C			A							
Smith's Millpond																	C			R		R			
Suggs Millpond															C			C							
*Sunset Lake					X				X											X					
Swamp Pond																	C				C				C
*Sweetheart Lake										X	X														
Lake Talasee					A											C				C			C		
*University Lake	X				X	X			X											X	X				
*Lake Waccamaw			X															X							
Wateree Lake					C	C											C		C	C					
*White Lake															C			C					C		

*Notes and Collections made by other Observers

* Explanation of Symbols

A - Abundant
C - Common
R - Rare
X - No Quantitative Record

Black Lake,* Bladen Co., N. C.: natural lake covering 2,100 acres (3 x 2 miles) and draining into South and Cape Fear Rivers; water in 100 cc. bottle light coffee color. 11/15/30.

Blewett Falls Lake, Anson and Richmond Cos., N. C.: large artificial lake on the Yadkin River covering 2,500 acres (15 x 1½ miles), depth at dam about 50 feet; transparency 3′6″; water in 100 cc. bottle yellow. 4/24/38.

Lake Brandt,* Guilford Co., N. C.: small millpond, draining through Haw River into Cape Fear River; transparency 2′2″. 10/25/31.

Bryant's Millpond, Bladen Co., N. C.: artificial lake covering about 800 acres, averaging about 5 feet in depth; water in 100 cc. bottle light yellow or amber. 2/13/38.

Crystal Lake at Lakeview,* Moore Co., N. C.: artificial lake, area estimated at approximately 70 acres, draining through Little River into Cape Fear River; transparency 4′3″; color in quart jar rather dark. 6/13/26 and 11/11/34.

Lake Ellis, Craven Co., N. C.: very shallow swamp lake covering about 1,450 acres (1¾ x 1½ miles) and draining through Hunter's Creek into Whiteoak River; water in the 100 cc. bottle clear. Some *C. albidus* and *C. agilis* Koch (*"C. serrulatus"*) besides the copepods listed. 1/15/38.

Everett's Lake, Richland Co., S. C.: small artificial lake (Fishing Club), covering about 100 acres; transparency 2′10″; water in 100 cc. bottle quite clear. Besides species mentioned in the Table, *Cyclops agilis* and *C. albidus* were found but only in the deep holes. 4/25/38.

Garner's Lake #1, Carteret Co., N. C.: swamp lake of about 15 acres, draining into Newport River; water in 100 cc. bottle quite clear. 1/15/38.

Garner's Lake #2, Carteret Co., N. C.: swamp lake covering about 4 acres, draining into Newport River. *Cyclops agilis* and *C. albidus*, also. 1/15/38.

High Rock Lake, Davidson and Rowan Cos., N. C.: large artificial lake on the Yadkin River covering 15,180 acres (25 x 2 miles), depth at dam about 60 feet; transparency 4′10″; water in 100 cc. bottle pale yellow. *Cyclops vernalis* Fischer, which is not typically limnetic, more numerous than the regularly limnetic *C. leuckarti* mentioned in the Table. 4/28/38.

Lake James, Burke and McDowell Cos., N. C.: large artificial lake on the Catawba River covering about 6,600 acres (approximately 10 square miles); transparency 5′; water in 100 cc. bottle clear. 4/5/38.

Jones Lake, Bladen Co., N. C.: natural shallow lake, covering about 550 acres (1½ x 1 mile), draining into Cape Fear River; water in 100 cc. bottle light yellow. 2/12/38.

Lennon's Millpond, Robeson Co., N. C.: artificial lake of about 1,200 acres over 100 years old, according to the owner of the property, and draining into Big Swamp River; very shallow—not exceeding 18 inches, except in region close to dam; wild fowl common; many islands and coves with much vegetation; water in 100 cc. bottle light amber. *Cyclops agilis* and *C. albidus* common. 2/13/38.

Loch Lily,* Person Co., N. C.: large millpond, draining into Flat River. 9/14/27.

Lookout Shoals Lake, Catawba, Alexander, and Iredell Cos., N. C.: large artificial lake on Catawba River, covering 1,270 acres (7 x 2 miles), depth at dam 78 feet; transparency 4′2″; water in 100 cc. bottle clear. 4/5/38.

Mark Creek Lake, Richmond Co., N. C.: artificial lake about 150 acres, draining into the Yadkin River; transparency 4′8″; water in 100 cc. bottle clear. 4/24/38.

Lake Mattamuskeet,* Hyde Co., N. C.: by far the largest natural lake in North Carolina, with an extent of about 35,000 acres (16 x 6 miles), draining the surrounding swamp and farming land and connected by canals with Pamlico Sound. (Collection by S. F. Hildebrand). 5/8/35.

Lake Michie,* Durham Co., N. C.: large artificial lake formed by dam on Flat River; water backed up in channel many miles; greatest depth at dam reported as 90 feet; transparency 2′5″; very little vegetation in shallows as observed; water in 100 cc. bottle yellow, owing to silt and clay.

Mills Pond,* Wake Co., N. C.: draining into Neuse River. 11/11/34.

Mountain Island Lake, Mecklenburg Co., N. C.: large artificial lake on Catawba River, covering 5,000 acres (16 x 1 miles), depth at dam 78 feet; transparency 3′7″; water in 100 cc. bottle clear. 4/6/38.

Lake Murray, Newberry, Saluda, and Lexington Cos., S. C.: large artificial lake on Saluda and Bush Rivers, covering 80 square miles, a shoreline of 525 miles, maximum depth at dam 200 feet; transparency 2′3″; water in 100 cc. bottle yellowish. 4/25/38.

Norwood Lake, Stanly and Montgomery Cos., N. C.: large artificial lake on the Yadkin River covering 5,000 acres (15 x 1¼ miles), depth at dam 70 feet; transparency 4′2″; water in 100 cc. bottle yellow. 4/24/38.

Odum's Millpond, Cumberland Co., N. C.: artificial lake covering 600 acres, draining into Big Swamp River, depth not reported; water in 100 cc. bottle clear. 2/13/38.

Ogburn Lake,* Rockingham Co., N. C.: millpond, draining through Haw River into Cape Fear River. 10/15/31.

Oxford Lake, Alexander and Catawba Cos., N. C.: artificial power lake on Catawba River, covering 4,110 acres (16 x 1¾ miles), depth at dam 90 feet; transparency 4′8″; water in 100 cc. bottle clear. 4/5/38.

Page's Lake, Bladen Co., N. C.: artificial lake covering 100 acres, draining into Big Swamp River; upper half separated from lower by wire screen; many cypress trees growing in water above "strainer" (weir); water in 100 cc. bottle clear. 2/13/38.

Perry's Mill,* Randolph Co., N. C.: Millpond, draining through Deep River into Cape Fear River. Only *Scapholeberis* found. 5/25/29.

Phelps Lake, Washington Co., N. C.: large swampy lake covering about 16,000 acres (7½ x 5 miles), with no apparent drainage system other than canals leading from the surrounding swamp into the lake; observed depth about 5 feet, but game warden reports depths as great as 20 feet or more in the center. Transparency 2′10″, restricted by dense growth of plankton algae near surface; water in 100 cc. bottle appears perfectly clear. 2/5/38.

Pungo Lake, Washington and Hyde Cos., N. C.: large swamp lake, covering about 4,000 acres (2¾ x 2¼ miles), with canals draining into Pungo River; water in 100 cc. bottle very slightly coffee color. 2/6/38.

Railroad Pond, Carteret Co., N. C.: swamp lake covering about 9 acres; water in 100 cc. bottle slightly discolored. A few *C. agilis* were found. 1/15/38.

(Roadside Canal), Tyrrell Co., N. C.: canal with very slowly moving water from small, very shallow swamp; water in 100 cc. bottle pale yellow. 2/6/38.

Little Singletary Lake, Bladen Co., N. C.: small rather shallow natural lake covering about 800 acres (2 x 1 mile) and draining into Cape Fear River; deepest part about 5 feet, average 3 feet; water in 100 cc. bottle dark coffee color. A few *C. albidus* were found. 2/12/38.

Skeet Club Pond, Lenoir Co., N. C.: small pond, about 4 acres, draining into Neuse River. Only *Cyclops agilis* were found. 1/16/38.

Smith's Millpond, Robeson Co., N. C.: artificial lake covering about 600 acres and with average depth of about 3 feet, draining into Big Swamp River; water in 100 cc. bottle with slight tinge of yellow. One *C. albidus* found. 2/12/38.

Suggs Millpond, Bladen Co., N. C.: shallow artificial lake covering about 1,260 acres (2 x 1 mile), draining into Cape Fear River; color of water in 100 cc. bottle light yellow. *C. agilis* found. 2/12/38.

Sunset Lake,* Wake Co., N. C.: draining into Neuse River. 11/11/34.

Swamp Pond, Craven Co., N. C.: typical shallow swamp pond, covering about 3 acres and 12 to 15 inches deep, no regular outlet. *C. vernalis* found. 1/16/38.

Sweetheart Lake,* Moore Co., N. C.: remains of an abandoned pond, now little more than a marsh. 10/26/29.

Lake Talasee, Montgomery Co., N. C.: large artificial lake on the Yadkin River, covering 5,050 acres (8 x 2½ miles), depth at dam 179 feet; transparency 4′8″; water in 100 cc. bottle yellow. *C. vernalis* forma *brevispinosus* Herrick found. 4/27/38.

University Lake,* Orange Co., N. C.: artificial lake covering about 200 acres; Cape Fear River system; transparency usually about 22″; water in 100 cc. bottle clear. Many dates, 1933–38.

Lake Waccamaw,* Columbus Co., N. C.: natural lake covering about 15,000 acres (5½ x 4 miles), draining into Waccamaw River; water has yellowish tinge. 11/29/29.

Wateree Lake, Kershaw and Fairfield Cos., S. C.: large artificial lake on Catawba River; transparency 2′5″; water in 100 cc. bottle pale yellow. 4/26/38.

White Lake,* Bladen Co., N. C.: natural lake of about 1,000 acres (2 x 1¼ miles), generally self-contained but with occasional overflow into Cape Fear River; depth not over about 9 feet; water remarkably transparent. 11/15/30 and 10/27/35.

OBSERVATIONS

The objective in this study was to learn something of the general nature of the crustacean plankton in the region. Littoral collecting was not, therefore, attempted, except in so far as was inevitable from the littoral nature of some of the waters as a whole. This accounts in part for the relatively few records of species of *Cyclops*, other than the notably limnetic *leuckarti*, *prasinus*, and *bicuspidatus thomasi*. Species of very general distribution such as *Cyclops vernalis*, *C. albidus*, etc. are omitted from this record. *C. fimbriatus poppei* is included because we have made a more careful identification than had hitherto been practicable. Doubtless it is only this subspecies which occurs in the State. *Cyclops nanus* is also included because we are offering the second record of the occurrence of this species in the Western Hemisphere.

Omitted from the Table also are all Cladocera except those species

which are characteristically limnetic or whose occurrence in the region is notable for other reasons. Our records of *Polyphemus* and *Leptodora*, for example (Coker, 1938), were the first for the southern region. One more locality in the State is added for *Holopedium*, since it was found abundantly in a large artificial lake in Richmond County. The genus was previously known east of Louisiana and south of the northern tier of states, only from Lakeview, Moore County (Coker, 1938).

The Daphnias collected have been grouped for purpose of record in two types: *Daphnia pulex* and *D. longispina*. The conditions of variation, both regional and seasonal, are so complex that authentic identification of the Daphnias of the *longispina* type can be effectively done only after the most exhaustive study. Our record, therefore, distinguishes merely the two groups. The Daphnias of Loch Lily are somewhat intermediate between *pulex* and *longispina*, having a distinct but not a prominent pecten with ocellus indistinguishable in the preserved material.

Comments on only a few species of cyclopoids are required. *Cyclops bicuspidatus thomasi* S. Forbes is distinguished from the type species principally by two features: The fourth thoracic segment of *C. bicuspidatus thomasi* has a papilliform posterior lateral process, and on the endopod of the fourth leg the outer apical spine is nearly twice as long as the inner instead of being only moderately longer (Gurney has found the relative length of these spines to be very variable even within the same brood); that terminal segment is quite long and the outer seta is recorded as extending beyond the outer spine, but the last mentioned character is not applicable to our examples, which otherwise possess the distinctive features of *thomasi*. *C. bicuspidatus thomasi* has also been taken from the Durham City Reservoir, and from pools about Chapel Hill (sycamore flats, pools across Bolin's Creek from Glen Burnie Farm, and a lagoon of New Hope River flats); in this survey it was found in three lakes of the Catawba River system.

In *Cyclops fimbriatus poppei* (Rehberg) the furcal rami are shorter and closer together than in the type species and the dorsal spinules of the rami reach nearly to the bases of the rami. Kiefer has treated *poppei* as a separate species with the remark that all American records of *fimbriatus* seem to refer to *poppei*, but we have followed Gurney in regarding *poppei* as merely a subspecies.

One more locality in North Carolina and the second record for the Western Hemisphere (Coker, 1938a) is established for *Cyclops nanus* Sars from Lake Talasee.

Attention may be directed to the very wide distribution of *Cyclops leuckarti* Claus and the much less general distribution of *C. prasinus* Fischer, these being two of the more regularly limnetic species of *Cyclops*.

Cyclops agilis Koch, generally known in America as *C. serrulatus*, is, of course, widely distributed in all types of waters. Its variability in some species, as to the proportions of the furca, is widely known. As of possible use in future investigations of the *agilis-speratus-macruroides* group in this region, the following record is made of the proportions of the furca as observed in examples from a number of waters. The copepods of the four waters last named are undoubtedly of the species now called *Cyclops agilis* Koch. Those of the first three waters we are

TABLE 2

Proportions of the furca for copepods of the agilis-speratus-macruroides group in certain waters in North Carolina

(Others unrecorded are found in North Carolina but the record is not within the scope of this report)

WATERS	COUNTY	$\frac{FW}{FL}$
Alligator Lake	Hyde	0.26
		0.23
Lake Ellis	Craven	0.2
Everett's Lake	Richland, S. C.	0.192
		0.228
Garner's Lake #2	Carteret	0.099
Lennon's Millpond	Robeson	0.111
Skeet Club Pond	Lenoir	0.138
Suggs Millpond	Bladen	0.105

not yet prepared to identify definitely as either *speratus* or *macruroides*. Some breeding experiments are being undertaken by a collaborator.

Harpacticoid copepods are so generally littoral in habit that their occurrence in plankton is commonly regarded as accidental. It is, then, of interest that only *Canthocamptus staphylinoides* new subspecies *vagus* and the closely-related *Canthocamptus sinuus* (formerly *C. staphylinoides* subspecies *sinuus*), and no other harpacticoids, should have occurred in 10 of McKee's collections, all in the lower Coastal Plain; the first-mentioned copepod is described elsewhere (Coker and Morgan, 1940) as a new subspecies of *staphylinoides* Pearse.

The only common species of *Diaptomus* encountered are *D. reighardi* Marsh and *D. birgei* Marsh, and their respective distributions are

peculiar.[1] Both are found in waters of eastern and western parts of the area studied and in very diverse types of lakes, both artificial and natural. They were never found in the same or even in neighboring lakes. Although thus rather widely separated, they occurred in the same drainage basin and even in power lakes in the course of the same river.

The only other species of *Diaptomus* recorded from North Carolina is *D. minutus* Lilljeborg previously known only from White Lake in Bladen County and Lake Waccamaw in Columbus County (Coker, 1938a), and now recorded from Little Singletary Lake and Suggs Millpond, both in Bladen County. A circle with a radius of 20 miles would encompass all of these waters.

Until recorded (Coker, 1938a) from White Lake, Bladen County, *Epischura nordenskioldi* Lilljeborg had not previously been known to occur south of Massachusetts. We now report it from Black, Little Singletary, and Page's Lakes and Suggs Millpond, all in Bladen County. Thus it is still known in the South only from one county of the Coastal Plain in North Carlina. A more intensive study of the waters of this particular region is much to be desired.

Eurytemora hirundoides Nordquist is the provisional identification (by Dr. S. F. Light) of a large calanoid found in Lake Mattamuskeet, Hyde County. The only other calanoid copepods recorded from North Carolina are *Diaptomus augustaensis* Turner and *Osphranticum labronectum* Forbes (Coker, 1938), but neither of these species was encountered in this survey.

SUMMARY

The plankton copepods of 15 natural lakes and 30 made ponds and lakes in the Carolinas, as collected on occasional visits, are reported. Records are also made for Cladocera of particular interest.

The cladocerans, *Polyphemus* and *Leptodora*, were not known from this part of the country until collected by McKee. For *Holopedium*, the second locality for the State and the Southeast is reported.

Cyclops bicuspidatus thomasi S. Forbes and *C. fimbriatus poppei* (Rehberg) are recorded. These subspecific names should probably replace the names of the type species in all records for the State.

A new form of *Canthocamptus staphylinoides* is found but is described elsewhere.

[1] We have other species of *Diaptomus* in North Carolina, but they were not found in the waters now under consideration and have not yet been definitely identified.

Two species of *Diaptomus*, *birgei* and *reighardi*, are found to be widely but very irregularly distributed. Two new localities in North Carolina are found for *D. minutus*, only two having been known previously. A species of *Eurytemora* is reported, and new localities are given for *Epischura nordenskioldi*.

Two copepods (*D. minutus* and *E. nordenskioldi*) and one cladoceran (*Polyphemus pediculus* Linné) each very far out of its known range, are still known only in southeastern states from a very restricted region that could be embraced within a circle with a radius of 20 miles (Robeson, Bladen, and Columbus Counties, North Carolina).

LITERATURE CITED

COKER, R. E. 1926 Plankton collections in Lake James, North Carolina—Copepods and Cladocera. Journ. Elisha Mitch. Sci. Soc. **41**: 228–258, pls. 34–44.

——— 1938 Anomalies of crustacean distribution in the Carolinas with list of cyclopoids of the general region of Chapel Hill, N. C. Journ. Elisha Mitch. Sci. Soc. **54**: 76–87, 16 text figs.

——— 1938a Notes on the peculiar crustacean fauna of White Lake, North Carolina. Archiv für Hydrobiologie **34**: 130–133, 1 text fig.

COKER, R. E., AND JUANITA MORGAN 1940 A new harpacticoid copepod from North Carolina. Journ. Washington Acad. Sci. (In press.)

BOOKS FROM CHAPEL HILL

TREES OF THE SOUTHEASTERN STATES. By W. C. COKER and H. R. TOTTEN. Second Edition. All the trees which grow naturally in Virginia, North Carolina, South Carolina, Georgia, Tennessee, and northern Florida are included. The more important naturalized trees are also included, as well as a list of native shrubs which occasionally reach tree size. Intended for the use of anyone interested in trees, whether high school student, college student, botanist, or amateur. About 417 pages and 248 illustrations. 4¼" x 7½". $2.00.

GROWING PASTURES IN THE SOUTH. By J. F. COMBS. Better pastures and grazing lands in the South will aid greatly in bringing about a more profitable and enduring type of agriculture, and will help to overcome the disastrous one-crop system of many southern communities. This book is not only an attempt to create greater interest in pasture improvement; it also furnishes the farmer and cattleman with detailed and practical information on how to develop pasture areas into profitable grazing lands; it contains enough technical information to make it useful as a text. Mr. Combs is a pasture crop specialist who for seventeen years has been Agricultural Extension Agent for the United States Department of Agriculture and A. & M. College of Texas. Seventy-eight illustrations, nine tables. About 280 pages. Size 5½" x 8¼". $2.00.

BIRDS OF THE SOUTH. PERMANENT AND WINTER BIRDS. By CHARLOTTE HILTON GREEN. "There has long been a need for a volume of this kind. Its author knows her birds both in books and in nature. She has been well advised and she writes attractively. In short, she has made a most acceptable addition to the literature of ornithology, one which because of its restricted field, popular form of presentation, and low price should do much to advance bird-study in the South."—F. M. Chapman in *Bird-Lore*. Bound in tan cloth with attractive design printed on cover. About 270 pages. Copiously illustrated with 32 color and 32 black and white pictures. Size 5½" x 8¼". 1934. $1.50.

THE NATURAL GARDENS OF NORTH CAROLINA. By B. W. WELLS. The first part of this volume is devoted to a general account of the eleven major plant communities in the state, from the windy dunes on the coast across the savannahs to the great forests and Christmas Tree land. The second part has a simple key which makes it easy to identify important species. "Dr. Wells has made a real contribution to botanical literature about a region rich with opportunity for such contribution."—*Nature Magazine*. About 470 pages. 210 halftone illustrations. 5½" x 8¼". $3.50.

THE UNIVERSITY OF NORTH CAROLINA PRESS
CHAPEL HILL, N. C.